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FUNDAMENTAL AND APPLIED RESEARCH.

SETTLED HOLDINGS IN THE TROPICS.

STUDIES IN TROPICAL LAND TENURE.

SOME FACTORS GOVERNING THE EFFICIENCY OF AFRICAN LABOUR IN BUSH-CLEARING WORK

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TROPICAL AGRICULTURE

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THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE. TRINIDAD, B.W.I.

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FUNDAMENTAL AND APPLIED RESEARCH.*

To the planter, concerned with his practical problems, fundamental research still seems to be something remote and mysterious, unlikely to be productive of results of use to him. Recently, however, interest in fundamental research has grown and the time seems appropriate for a discussion of what we mean by this type of research and the respective parts that fundamental and applied research can play in agricultural development.

It has long been apparent that the value of fundamental research is fully realised by such bodies as the Empire Cotton Growing Corporation. This is well exemplified by the work of the Cotton Research Station in Trinidad, and by the recent decision of the Corporation substantially to increase its research personnel in Africa. Among others, an entomologist, having special knowledge of and training in insect physiology and biochemistry, has been appointed to undertake a detailed study of the fundamental problems of the attraction of bollworms and stainers to the cotton plant and of their nutrition on this plant.

A new five-year programme of research into the fundamental problems of the storage of tropical fruit and vegetables is now in progress at the Imperial College of Tropical Agriculture, the Low Temperature Research Station having been largely reconstructed, and new facilities having been provided, for this purpose. The banana is being especially studied, the aim being to explore, by physiological, biochemical and cold storage investigations, the possibilities of improving on the size and quality of fruit exported overseas. The banana is also receiving the continued attention of the Botany Department, for, not only are genetical studies being extended, but arrears are being made up in the fundamental cytological work.

It is by no means easy to grasp the distinction between fundamental and applied research, or, for one who grasps it, to explain the distinction. To say that fundamental research aims at discovering those foundations of knowledge upon which applied research should be built does little to remove the difficulty. In practice it is convenient to say that fundamental research is essentially the kind of work done by a Research Station, applied research essentially by the work of an Agricultural Department. The distinction

* Adapted from an article by H.H.S. in *East African Agric. Jr.*, Vol. III, No. 4, pp. 241-244, 1938.

between the two branches is far from being clear cut, and this convenient method of division is not always true, for some Departments do a considerable amount of fundamental research.

The problem of shade presents a simple example of the methodology of fundamental and applied research. Applied research approaches this problem with no knowledge on which to form an hypothesis for the optimum conditions of shade. Under these circumstances it could do no more than lay down an experiment comparing different kinds and different intensities of shade. Now an experiment like this can provide only one piece of information: that in such-and-such a locality the best results are given by such-and-such a form of shading. Since the experiment gives no evidence concerning the manner in which shading has influenced the functioning of the plant, it is impossible to say whether the results obtained in the one locality will apply in another. The only course is to carry out another experiment there. So experiments multiply, results are discordant, and we are still left with no theory of shade that can form a satisfactory basis for an advisory service.

The approach of the fundamental worker to this problem is quite different. He studies the physiology of the plant under different conditions. At this stage in his research the effect of shade is only incidental to the study of the way in which the plant functions. As is now well known, these studies reveal that the stomata close and carbon assimilation ceases when the leaf is exposed to full sunlight. Under a cloudy sky or any form of shade the stomata remain open and carbon assimilation proceeds. We may reasonably assume that conditions favouring this process, since it provides the plant with its carbohydrate reserves, also favour the general well-being and productiveness of the plant.

Here then is a theoretical basis upon which a policy for shade can be formed, but it is not the final solution of the practical problem. It provides a working hypothesis for the applied worker, but its application to practice must await the results of experimental trials. It is evident that, equipped with a guiding principle, the applied worker can design his experiments with much more economy than previously and can expect to obtain conclusive results much earlier. By studying the climate of each locality and the occurrence of clouds, he can form an opinion of the requirements of the plant for shade, but he must still carry out his trials. Only when these trials have shown that there is no unsuspected fallacy can he safely advise the planter. We should note, however, that in all possibility fundamental research has not finished the contributions that it can make to this problem. The applied trials may well reveal unsuspected fallacies, shade may be found to influence other functions of the plant, so that what is ideal for maximum carbohydrate production may prove to have compensating disadvantages. Then once more it may be necessary for fundamental research to study another aspect of the functioning of the plant.

From a consideration of the foregoing we may appreciate certain important principles. The first is that economy is generally obtained if fundamental precedes applied research. Once fundamental research has supplied a working hypothesis, the task of the applied worker is greatly shortened. In agricultural research, applied work has tended to precede fundamental work and undoubtedly it has solved successfully many problems. Some problems it has failed to solve, and unassisted by fundamental research, is unlikely ever to solve. Ideally the applied agricultural research worker should start only when fundamental research has completed its task. In practice, fundamental research tends to come in at a late stage only when applied research has perceived that some of its problems are insoluble by its methods. Fundamental research would have simplified the whole task of the applied worker. Once fundamental research has shown how the plant functions, the applied worker is equipped not only to solve the problem of shade, but probably many other problems in the cultural treatment of the plant. The results of fundamental research hold for all times and all places. A third important point is that within an ideal research service fundamental and applied research are complementary and interrelated one to the other. If the applied worker is often entirely dependent on the fundamental worker, and always greatly helped by him, the community is entirely dependent on the applied worker for translating into practical form the findings of fundamental research. The applied worker is the essential link between all research and practice.

A tendency is evident to regard the fundamental worker as a superior being, and for the applied worker to feel that his status is inferior. This is a fallacy. The qualifications required for each are different. If the fundamental worker needs the greater academic qualification sand more profound scientific knowledge, the applied worker must possess the balanced judgment, experience and human understanding that make him both a scientific and a practical man. Both workers have honourable tasks to perform for human welfare.

Control of research, whoever exerts it, requires a special interpretation. Research is a thing of two parts, first the collection of data, and secondly, the interpretation of the data by exact analysis. Into the latter enters that intangible quality of the good research worker, inspiration or genius, without which research is sterile and lifeless. In the building of a research service the first need is a staff mentally equipped to perform the second function, and the second need is to provide conditions that encourage him to use this mental equipment. Too much organization drives out genius and leaves no time for thought. Control of research really means the study and understanding of the individual research worker, his encouragement and guidance into those lines of research that he is likely to make productive, and the appreciation of the results that he obtains.

SETTLED HOLDINGS IN THE TROPICS.

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Part I.

For various reasons, settlement schemes are receiving serious consideration from many Tropical Administrations. Such schemes are of two kinds. In the first case, there may be a considerable agricultural population living on the land, but not settled on it, that is to say they are practising shifting cultivation. It is now generally recognised that this form of cultivation, with its attendant evils, is a luxury which most countries can no longer afford, and methods are being sought to persuade the peasant to live permanently on his holding. In the second case, the Government, for various reasons, desires to see a fair proportion of their landless population settled prosperously on the land, and enjoying what are generally admitted to be the healthier conditions of a rural, as opposed to an urban, life.

In both cases, the maintenance of the soil fertility is of the first importance in any settlement scheme, for unless a system of farming is adopted which will return to the soil a sufficient proportion of what is taken from it, yields must gradually drop and the holder will have to quit.

An experiment started on the College Farm eight years ago, which is now for various reasons being discontinued, has a distinct bearing on these problems. It was originally planned as a fertility experiment, under postulated conditions such as obtain in large parts of Africa which preclude the keeping of livestock of any kind. Actually, for the sake of economy and convenience, animals were utilised in tillage operations, in planting and intercultivating. A tractor was also used for preliminary cultivation purposes.

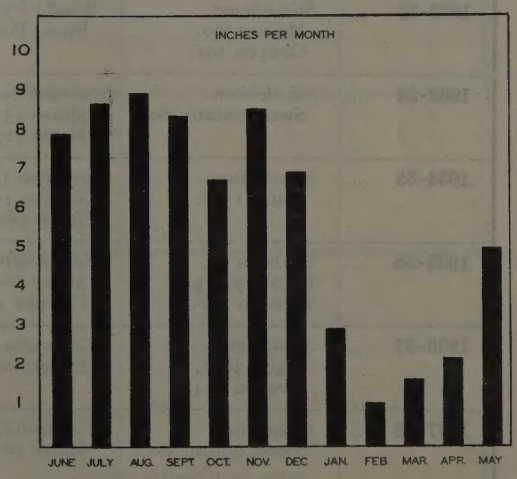
The experiment occupied a block of six acres of land which was divided into four fields, each representing one year of the four-year rotation which was adopted. The soil is particularly poor, being a detrital sandy-loam somewhat re-worked by stream action, derived from the quartz-schists which comprise the main rocks of the Northern Range of Trinidad. Its content of coarse and fine sand is about 50 per cent.; having been dressed with lime, it is slightly alkaline in reaction, and it contains only about 1.5 per cent. of organic matter in the surface 6-inch layer. Available potash is notably deficient (35 p.p.m. K_2O) and available phosphate slightly deficient (30 p.p.m. P_2O_5). After three years cropping it became evident that the land was so deficient in phosphoric acid and potash that it could not grow normal crops at all, and accordingly, a dressing of 3 cwts. muriate of potash (costing $6.75) and 4 cwts. of superphosphate of lime (costing $4.50) an acre, was applied to the whole area. In May 1931, a full dressing of ground limestone at 7 tons to the acre was given. No nitrogenous manure was given at any time.

The land was very patchy, and this condition was responsible for areas of good and areas of poor crop being found in close juxtaposition. This was due partly to the land having only been taken into cultivation in January 1929, and had previously comprised a number of small holdings, interspersed with coconut plantations, clumps of bamboo, mango trees and such like, with small houses here and there, and partly to the fact that a great deal of levelling had to be done.

In June 1929, a crop of maize was planted over the whole area and this was followed by a mixed crop of cotton and maize which grew fairly well. This was off by June 1930, when the experimental rotation started.

There is in Trinidad, a rough distinction between the wet and the dry seasons, but the duration of these varies, and sowing is possible almost throughout the year. The cropping season may conveniently be said to start in June, and the rainy season lasts, with falls of varying intensity, until the middle of January. Normally February, March and April are dry, and in May, the onset of the rainy season may be expected. The diagram shows the average rainfall at the Imperial College of Tropical Agriculture for the eight years of the experiment.

TRINIDAD RAINFALL



AVERAGE FOR EIGHT YEARS OF EXPERIMENT 1930–1938

The system of cropping adopted was as follows :—

YEAR IN ROTATION.

I *Stizolobium* sown as early as possible (April-May) and turned under in November for a crop of *maize*, lasting until February.

II *Pigeon Pea* in lines intersown with *soybeans* in June. The *soybean* is lifted in October and *cotton* or *tobacco* planted between the lines of pigeon pea.

III *Maize* sown in June, followed by *cowpeas* (Vigna sinensis) in November.

IV *Stizolobium* sown in April-May turned under for *sweet potatoes* (Ipomoea batatas) in November.

There have been two complete rotations since the experiment started, comprising sixteen successive crops.

Certain modifications have been made in the scheme since it was started. It was found that the cropping outlined above left the land bare for considerable periods between crops. In this condition, heavy losses are likely to occur from the leaching of the soil, and accordingly it was arranged that extra short-term green manure crops should be grown whenever possible. As a major green-manure crop *Stizolobium* was not found very satisfactory, and *Canavalia* was substituted for it towards the end of the rotation. Cotton, after four years, was discarded in favour of soybeans.

The general idea in constructing this rotation was to supply the needs of the settler and his family for food and money, and at the same time to grow enough green-manure crops to maintain the fertility of the land. It will be seen that the food crops include a CEREAL, *maize*, which in view of its importance was grown both as an early and as a late crop, PULSES, including *pigeon pea* (Cajanus cajan), *cowpea* (Vigna sinensis) and *soybean* (Glycine max), and a ROOT CROP, *sweet potato* (Ipomoea batatas). The MONEY crop was *tobacco*.

The full yields obtained during the eight years of the experiment are shown in Table I.

Table I.

Complete Yields for the Course of the Experiment.

YEAR.	BLOCK A.	BLOCK B.	BLOCK C.	BLOCK D.
1930–31	*Stizolobium.* Maize 3192.	Soybean 64. Cotton 100. Pigeon pea 330.	Maize 1990. Cowpea 202.	*Stizolobium.* Sweet potato 1039.
1931–32	Soybean 420. Tobacco 50. Cotton 130. Pigeon pea 65.	Maize 3728. Cowpea 95.	*Stizolobium.* Sweet potato 6820.	*Stizolobium.* Maize 1892.
1932–33	*Stizolobium.* Maize 1300. Cowpea 191.	*Woolly Pyrol.* Sweet Potato 1924.	*Canavalia.* Maize 1118.	*Woolly Pyrol.* Tobacco 93. Cotton 33.
1933–34	*Stizolobium.* Sweet potato 2695.	*Stizolobium.* Maize 1337. Maize 727.	*Sunnhemp.* Soybean 210. Cotton 428.	*Woolly Pyrol.* Maize 3432. Cowpea 164.
1934–35	*Stizolobium.* Maize 1568.	Soybean 120. Tobacco 102. Pigeon pea 193.	Maize 4108. Cowpea 11.	*Stizolobium.* Sweet potato 5207.
1935–36	Soybean 90. Pigeon pea 540. Tobacco 162.	*Sunnhemp.* Maize 2858. Cowpea 100.	*Stizolobium.* Sweet potato 5836.	*Stizolobium.* *Sunnhemp.* Maize 1738.
1936–37	*Sunnhemp.* Maize 2041. Cowpea 144.	*Canavalia.* Sweet potato 3363.	*Stizolobium.* Maize 2467.	Soybean (failed). Tobacco 50. Pigeon pea 284.
1937–38	*Canavalia.* Sweet potato 5018.	*Canavalia.* Maize 2006.	*Canavalia.* Soybean 64. Pigeon pea 483. Tobacco 22.	*Sunnhemp.* Maize 2082. Cowpea 80.

All figures in lb. per acre. Maize yields are weights of cobs as harvested. Tobacco, weights of cured leaf. Cotton, weight of seed cotton. Crops italicised were turned under for green manure.

In order to trace the fertility status of the land, three tables have been prepared showing the yields of the three main crops throughout the period. They are early maize, late maize and sweet potato.

For a comparison with some of the above figures, the yields of maize from the permanent manurial plots on the College farm are given in table V.

Table II.

Yields of Early Maize.

Year.	Plot.	lb. per acre.	Date of sowing.	Remarks.
1	C	1990	July 17	Suffered from drought in early stages.
2	B	3728	June 17	
3	A	1300	July 14	Poor germination and early growth.
4	D	3432	July 12	Manured : Woolly Pyrol (May).
5	C	4108	July 16	An excellent crop.
6	B	2858	July 16	Borer rather severe.
7	A	2041	Aug. 25	Soil condition poor.
8	D	2082	Sept. 14	
MEAN		2692		

Weights of cobs as harvested.

Table III.

Yields of Late Maize.

Year.	Plot.	lb. per acre.	Date of sowing.	Remarks.
1	A	3192	Nov. 14	Dry weather but the crop grew well.
2	D	1892	Nov. 24	Poor germination and thin crop.
3	C	1118	Nov. 5	Patchy.
4	B	1337 727	Aug. 15	Mistake : sown again December, 30, but very dry.
5	A	1568	Dec. 20	Very dry and attacked by insects.
6	D	1738	Nov. 9	Suffered from drought.
7	C	2467	Sept. 18	
8	B	2006	Nov. 30	
MEAN		2005		

Weights of cobs as harvested.

Table IV.

Yields of Sweet Potatoes.

Year.	Plot.	lbs. per acre.	Date of planting.	Remarks.
1	D	1039	Dec. 5	Weather dry : Megastes attack severe.
2	C	6820	Oct. 24	Planted on flat : a full stand.
3	B	1924	Oct. 28	
4	A	2695	Nov. 14	A dry season.
5	D	5207	Oct. 6	
6	C	5836	Oct. 1	
7	B	3363	Sept. 15	Very severe attack from slugs.
8	A	3346	Oct. 1	
MEAN		3779		

Table V.

Yields of Early Maize Crops on the Permanent Manurial Plots.

TREATMENT.	(4) **1932** Aug.-Nov.	(7) **1933** Sept.-Dec.	(10) **1934** Aug.-Dec.	(14) **1935** Sept.-Dec.	(19) **1937-38** Oct.-March.
Complete mineral, lime and organic manure. (Plot 2)	1640	3680	3880	3140	4060
Lime, phosphoric acid, and potash only. (Plot 15)	1860	2460	1880	2780	1600
Lime only .... (Plot 12)	1140	2560	1900	1740	1700

Yields in lb. per acre of cobs as harvested.

Plot 2 represents the highest manurial treatment that is given, while Plot 15 has been included in order to show the effect of giving phosphoric acid and potash only, and is therefore more strictly comparable with the rotation experiment under discussion.

An examination of these figures shows that the yields keep up fairly well, and that there are no definite signs of soil exhaustion. There is no doubt however that soil conditions have not improved, and difficulty is experienced at times in obtaining a good stand. The soil seems less easy to till than similar lands in the vicinity, receiving better manurial treatment.

Part II.

The results of this experiment have a distinct bearing on the current settlement problems of Trinidad, for besides the information they throw on the general question of fertility, certain conclusions can be drawn as to the area suitable for a settler and his family, and further as to the economic return obtained by him for the labour he would have to devote to his holding.

It is assumed that in the conditions described above, and with the rotation adopted, the fertility of the soil will be indefinitely maintained. The rotation is sound in its general arrangement, but of course, minor modifications could be made in it, without upsetting the general idea. Other root-crops can be grown besides sweet potato, and a greater variety of pulses, oil-seeds and condiments may be grown so long as the restorative crops are not reduced. Further the crops may be grown in mixtures instead of in pure cultures as in the present case.

The diets of dwellers in the tropics, engaged in manual labour, have been studied by various workers (1) (2), and there is a general agreement that *at least* 3,500 calories are required daily, for a man doing hard physical work, though many of the diets actually recorded in Trinidad fell lamentably short of this standard (2).

For purposes of discussion, the peasant's household may be considered to consist of himself, his wife, and three children, a boy of 12, and two girls of 10 and 6. The daily requirements of this unit would then be roughly as follows (3). (*See* table VI.)

Table VI.

Individual.	Proportion.	Requirements.
Peasant	1,00	3,500 calories
Wife	.83	2,905 do.
Boy (12)	.85	2,975 do.
Girl (10)	.70	2,450 do.
Girl (6)	.60	2,100 do.
Total	3.98	13,925, say 14,000 calories.

The average yields obtained for the eight years of this experiment are tabulated in table VII.

Table VII.

Average Yields per acre.

Maize	
Early Crop (2692 lb. cobs)	1669 lb. grain
Late Crop(2005 lb. cobs)	1243 do.
Pulses	
Pigeon pea	587 lb. grain
Cowpea	130 do.
Soybeans	131 do.
Root Crops	
Sweet potatoes	3779 lb. tubers

From these it is possible to calculate the area that will produce the food needed. (Table VIII.)

Table VIII.

Average Annual Production and Area Required to Produce Food Needed.

Crop.	Obtained from 1 acre (lb.)	Obtained from 7-8 acre (lb.)	Daily yield from 7-8 acre (lb.)	Equivalent in calories.
Maize	2912	2548	7	10,000
Pulses	848	742	2	3,000
Sweet potatoes	3779	3307	9	3,000
			Total	16,000

It is thus seen that the produce from four fields, each 7/8ths acre in extent, or a total of 3½ acres, should normally provide sufficient food for the family under consideration.

What are the labour requirements of such an area and are they within the capacity of the settler? To take the most severe conditions, it is assumed that he has no animals, and that all operations must therefore be performed by hand. It is not possible to calculate the labour needed directly from this experiment, for, as stated above, full use has been made of mechanical and animal power in cultivating the land, but the figures given below, of man-days needed per acre have been carefully estimated, and checked with figures from Nigeria (4). They include the labour needed for growing the preliminary green-manure crops and for turning them under. (*See* table IX.)

Table IX.

Cultivation of Crops in Man-days.

Crop.	1 Acre.	⅞ Acre.
Maize: early	50	44
Maize: late	82	72
Pigeon pea: Soybeans	64	56
Tobacco	150	15*
Cowpea	40	35
Sweet potato	85	75
Miscellaneous: composting: additional green-manures	—	22
Total	—	319

*1/10 acres.

To this must be added the labour needed for the tobacco crop. As the area is small, and as all of the handling, harvesting, curing, sorting and bundling is done by the girls, a total of 15 man-days should suffice.

This total of 319 days will be made up somewhat as follows. (*See* table X.)

To meet his money requirements, the settler will depend on what he can make by working for hire, and by the sale of his tobacco, and any surplus food-crops. Part-time employment offers some difficulty, but it is not unreasonable to suppose that the three oldest members of the family could each put in 100 days a year—two days a week—working for hire, and this would bring in $50.00, $40.00 and $30.00, a total of $120.00.

The tobacco crop is most variable and the average is not very reliable. A crop of 100 lb. of cured leaf from 1/10 acre would bring in about $30.00, assuming 15 lb. first grade at 50 cents, 70 lb. second grade at 30 cents, and 15 lb. third grade at 10 cents.

The situation then is that on 3½ acres of poor land the settler and his family can produce all they require in the way of food without depleting soil fertility and can earn in addition, a sum of about $160.00 a year to meet their cash requirements. There are further points to be considered, the most obvious of which is to ascertain whether this is an economic return for the labour expended: in other words, would the family be better off if they worked entirely for hire and purchased their food with the wages they received? The value of the food produced is given below: the prices are generally speaking, what would be obtained at harvest time. (*See* table XI.)

The amount of labour to produce these has already been given, and to this labour a value may now be given. From figures collected by Shephard (5), the average daily earnings obtained

Table X.

Labour Requirements for the Holding.

Class of labour.	No. of days.	Equivalent in man-days.
Man	150	150
Woman	100	66
Boy	100	66
Girl	75	25
Girl	50	12
	Total	319

Table XI.

Value at Harvest Time of Crops Raised.

Crop.	Yield.	Rate per lb. c.*	Value $
Maize	2548	1½	38
Pulses	848	3	25
Sweet potato	3307	1½	49
Tobacco	100	—	40
		Total	$ 152

*A Trinidad cent is approximately one half-penny.

by an East Indian man, working on sugar estates was in 1928-29, 46 cents, the figure for a West Indian man was slightly higher, 53 cents. The figures for women were 29 cents and 30 cents respectively. On cacao estates, the figures were, for men 49 and 51, and for women 31. Rates have gone up considerably since then, and a fair figure now may be taken as 55 cents and 40 cents.

In the conditions of the experiment, *i.e.* with all the work performed by hand, and at the values given for produce, it seems clear that the settler and his family do not get a full economic return for their labour. It may be noted however, that the prices quoted are those generally prevailing at the time of harvest, and that better prices can be expected, if the produce can be kept back from the market. The price of maize at one of the leading stores in Port-of-Spain was found to vary from 3.19 cents to 1.81 cents throughout the year.

Further the use of cattle, to be mentioned later, will considerably reduce the number of days necessary to produce the crops under consideration and will provide manure, and finally it must always be remembered that from the man working on his own land, the bogey of unemployment is banished.

The next point to consider is whether the settler's labour can be utilised evenly throughout the year, or whether the work to be done on the land reaches such a peak at certain seasons as to make it impossible for him to cope with it. The table below indicates the labour requirements during the year. (*See* table XIII.)

It will be seen that there are busy months, and during them at any rate, it will be impossible to accept any outside work for hire. It is a difficulty which is recognised, that the demand for agricultural work will be at its greatest just at the time when he is busiest on his own land.

Table XII.

Value of Labour Expended in Raising Crops.

Class	No. of days.	Rate c.	Value $
Man	150	55	82.00
Woman	100	40	40.00
Boy	100	30	30.00
Girl	75	18	13.50
Girl	50	12	6.00
		Total	171.50

Table XIII.

Labour requirements during the year (Figures in brackets signify man-days).

Month.	I	II	III	IV	Total Man-days.
June	Weed *Stizolobium* (8)	Cult. and planting for pigeon pea and soybeans (12)		Weed *Stizolobium* (8)	28
July		First weeding for pigeon pea and soybeans (10)	Cult. and planting for maize (14)		24
August		Second weeding for pigeon pea and soybeans (10)	First weeding for maize (12)		22
September			Second weeding for maize (10)	Turning under *Stizolobium* Cult. for sweet potatoes	30
				Ridging and planting sweet potatoes (20)	26
October		Harvesting soybeans (8)	Harvesting maize (8)	First weeding for sweet potatoes (10)	22
November	Turning under *Stizolobium* Cult. for and planting maize (18)	Planting tobacco (4)			
December	First weeding maize (10)	First weeding tobacco (2)	Cult. for and planting cowpeas (12)	Second weeding for sweet potatoes (10)	34
January	Second weeding maize (8)	Picking green peas (4) Second weeding tobacco (2)	Weeding cowpeas (10)		24
February	Harvesting maize (8)	Picking green peas (4) Handling tobacco (2)		Begin lifting sweet potatoes (5)	19
March	Composting straw (4)	Harvesting tobacco (5)	Picking cowpeas (13)	Start lifting sweet potatoes (5)	27
April	do.	Picking pigeon peas (4)	Composting straw (4)	Finish lifting sweet potatoes (5)	17
May	Cult. for and planting *Stizolobium* (12)	Clearing pea stalks (4)	do.	Cult. for and planting *Stizolobium* (12)	32
					305

The diet outlined in paragraph 6 above, lacks variety, but a stronger criticism of it is that it is deficient in animal fats. This deficiency can best be met by keeping livestock and this point is sufficiently important to need special consideration.

The value of working animals, oxen or mules, for economising the manual labour required for cultivation, has already been mentioned. Equally valuable is the keeping of a cow or a goat for milch purposes, or a pig for providing the family with an occasional meal of animal flesh and fat. From figures obtained here, a pig in Trinidad will gain an average of .77 lb. a day and will weigh at 6 months about 120 lb. when it can be sold for 7½ cents a lb. live-weight.

The goat is a most valuable milch animal, and is hardy and prolific (6). Its milk is excellent in quality and with proper precautions most palatable. The value of poultry, from the dietetic point of view is high, both for eating and for the sake of the eggs they produce. Moreover chickens, and guinea fowl, the latter particularly, are great insect-eaters, and help to keep down the pests that attack the crops.

Mention was made above of the value of livestock for the purpose of making manure. Raw material, in the shape of maize straw, cobs and husks (two crops), sweet potato haulms, cowpea vines and other vegetable matter is abundant, and it should be possible to return a large proportion of this material to the soil in a fermented condition, as manure or compost. Even if animals are not kept it has been shown (7) that with care and a moderate expenditure of labour, excellent compost can be made from maize straw; if animals are kept, the process is facilitated and accelerated.

The question of the storage of food grains in Trinidad needs consideration. Unless precautions are taken, both cereal and pulse grains deteriorate very rapidly, and if home-grown produce is to be available all the year round, storage for a considerable period will be necessary in some cases. The table below shows the dates of harvest of the principal crops and the number of days supply they provide:—

Table XIV.

Crop.	Date of harvest.	Days supply.
Early maize	November	210
Soybeans	October	53
Late maize	March	154
Cowpea	March	53
Pigeon pea	April	259
Sweet potatoes	February-April	360

Part III.

The experiment has shown the possibility of land settlement in the conditions described, and indicates the difficulties that face any scheme for settlement in Trinidad. Whether or not it is sound policy to try and attract settlers to the land, it is clear that it will be neither an easy nor a cheap proceeding.

The maintenance of the fertility of the land is the first necessity for success, but this fertility must not be maintained at too low a level. If an initial manuring, as in the present case, is deemed necessary, it should be *compulsory*, and it would be better undertaken by the settlement authority, before the settler was established on the land. The cost, in this case $12.00 an acre, may be included in the general cost of the settlement, or may be recovered in instalments from the tenant.

The use of green-manure crops must also be made *compulsory* and considerable difficulty will be experienced in this, for the practice is novel and the crops grown are unfamiliar. Every help should be afforded in the way of the supply of the necessary green-manure seeds, either free or at cost price, at any rate at the start of the scheme, for it will be too much at first to expect the tenant to grow his own seed.

Where conditions do not prevent livestock being kept, every encouragement should be given under any scheme of settlement to the practice. The keeping of livestock, whether cattle, sheep, goats, pigs, or even chickens not only helps to increase the fertility of the land, but greatly improves the quality and the variety of the settlers' rations. It would be wise in many cases to make the possession of stock *a necessary condition* for the settler to obtain his land, and to provide facilities for him to acquire good quality stock if he cannot do so unaided.

The provision of some arrangement for the storage of the settlers' food-grains and ground, provisions *is strongly indicated*. It is almost impossible for the individual to undertake this, and it will probably be necessary to erect some kind of communal store. To what extent centralisation should take place, would depend on circumstances, such for instance as the cost of transport, but it is certain that unless the settler can store his grains, he will be compelled to sell. He will obtain bottom prices, and will inevitably spend the money thus obtained, and will then be compelled to work for hire, and his holding will suffer. An additional advantage of centralising this store and bulking the grain will be the cultivation of a standard type of grain which may well be an improved strain supplied by the settlement authority.

References.

1. Leitch, J. Neil.—Dietetics in Warm Climates. *Harrison & Sons*, 1930.
2. Seagar, E. A.—Labour Efficiency. *Tropical Agriculture*, VII, 40.
3. Hutchinson, Robert and Mottram, V. H.—Food and the Principles of Dietetics. Seventh edition, p. 70 *Arnold*: London, 1933.
4. Nigeria Agricultural Department. *Eight and Ninth Annual Bulletins.*
5. Shephard, C. Y.—Imperial College of Tropical Agriculture: Trinidad. *Unpublished data.*
6. Shannon, J. L.—Care and Management of Dairy Goats in Trinidad. Agriculture Department of Trinidad and Tobago, 1932.
7. Wood, R. Cecil.—Experiments on Compost Making. *Unpublished.*

SOME FACTORS GOVERNING THE EFFICIENCY OF AFRICAN LABOUR IN BUSH-CLEARING WORK.

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I. Introduction.

Felling of bush still plays an important rôle in the reclamation of land from tsetse, for it is frequently necessary to divide up by means of wide clearings the huge tracts of infested woodland into more manageable blocks which may then be attacked one at a time. The labour employed for the purpose falls into two categories. Firstly, large gangs of voluntary and unpaid tribal labour which work for no longer than ten days and in that short time acquire little skill and secondly, smaller and highly organised gangs of paid men who have often had previous experience and work for at least a month and sometimes much longer. This paid labour has a day of eight hours, but often little more than seven is actually spent on the work as allowance has to be made for getting to and returning from the site of operations. The important problem of increasing the efficiency of both these types of labour is one that has received considerable attention from the Department of Tsetse Research in the past and some of the results have been recorded in two papers by the senior author, "Notes on Anti-Tsetse Clearings" (Government Printer, Dar-es-Salaam, 1932) and "Task-work *versus* Day-work Methods in Anti-Tsetse Clearings", (*Tropical Agriculture*, Vol. X, No. 9, pp. 249-254, 1933). The former is of a general nature and where it touches on labour deals chiefly with the organisation of the large tribal labour gang, while the latter explores the possibility of increasing the output of paid gangs by the task-work method.

This paper describes how the investigation has been carried a step further. An attempt has been made to obtain improved results by such means as testing the efficiency of various types of axes, by introducing rest-periods for the labour and by supplying food during these breaks in the work. Some of the results are applicable to tribal labour, others only to paid labour gangs and the remainder to both. The experiments were carried out at Shinyanga in the Lake Province of Tanganyika Territory in 1936, most of them between February and August.

As the question of increasing the efficiency of native labour is one that is of interest to all employers, it is hoped that the experiments described here may be of interest to a wider circle than that immediately concerned with the solution of the tsetse-fly problem.

2. Outline of the Method of Experiment.

General

As far as the human factor was concerned there was the choice of two alternative methods in planning the experiments—either individual (using, for example, the new pattern axe to be tested) might be pitted against individual (the control), or a broader basis might be adopted and gang tested against gang. The latter method was chosen as likely to give more reliable results. But to ensure such results it was necessary also to devise some more accurate method than merely setting the experimental gang to fell the bush over an area which seemed equally densely treed as that allotted to the control gang. Unless that system were followed on a very large scale—out of the question in these experiments—the results would be open to doubt, for inspection showed the rapid changes in density, size and species of trees in the Acacia-Commiphora savanna at Shinyanga. It became necessary, then, to attach a "felling value" to each individual tree so that the sum of the work performed by a gang could be accurately assessed. But because there is a difference in the hardness of wood of different kinds of trees this felling value could not be governed solely by girth: the species of tree had to be taken into account too. It was of course impracticable to find the felling value of all sizes of all species, and thus permit a gang to cut straight ahead in an experiment felling everything that presented itself. So a typical and common representative of the hard-wooded trees—*Acacia spirocarpa*—and one from the soft-wooded trees—*Commiphora Fischeri*—were chosen. By experimenting on two species of different hardness it would be possible, for example, to tell whether a method that had been proved to give good results with hard-wood, and was being applied successfully in an area where trees of that sort were dominant, would be equally successful in another area where the chief trees were soft-woods. The experiments described were, then, confined to these two species, but in no case of course did more than one enter into a single experiment.

Felling Values of *Acacia spirocarpa* and *Commiphora Fischeri*.

A satisfactory felling value—in seconds—could be assigned a tree in terms of the length of time it would take a native to cut it down. Were that native above or below the general standard at Shinyanga would not matter as long as the quality of his work was constant. But in practice such constancy could not be achieved for fatigue greatly lengthened the time taken to cut down trees during the latter part of the day as compared with the early part even though they might be of similar circumferences. The difficulty was overcome by eliminating the fatigue factor altogether. It was found that a native could work for a period of three minutes without showing perceptible signs of fatigue. Gangs of suitable sizes were apportioned to every tree so that no individual was required to work longer than

three minutes at a stretch as measured by a stop-watch and then was given at least a 27-minute rest when cutting Acacias and a 12-minute rest when cutting the soft-wooded and less exhausting Commiphoras, before he was called on for his next three minute turn. Thus a tree was subjected to a high pressure bombardment by a succession of natives in fresh condition from the time the attack opened to the time the tree fell. A very large number of individuals participated in this work so that the results incorporated in the "felling curves" described below may be regarded as representing the capabilities of the *average* Shinyanga labourer. This fact is of no material importance in considering the results of experiments but it nevertheless adds to the interest, as the standard of the experimental gang may in many instances be compared with that of the average gang. Each native was supplied with the type of axe that is ordinarily used by the labour at Shinyanga, namely, the European ring-head pattern, 2½ lb. in weight and with a home-made shaft about 24 inches long (*see* fig. 1). During this rest spell he sharpened it up so that output should not deteriorate through increasing bluntness of the tool. He also had access to all the drinking water he required.

Inspection showed that *A. spirocarpa* trees were available in sufficient numbers from a circumference of 18 inches, measured at 30 inches above ground-level (*i.e.*, as low as it is comfortable for the native to cut this tree) to 48 inches. Accordingly 50 trees of regular conformation of each of the following circumferences were selected, 18, 24, 30, 36, 42, and 48 inches, and the length of time of felling of each was recorded. From these data the graph shown in fig. 2 was drawn. In the case of *C. Fischeri* 75 trees of each of the following circumferences were felled: 12, 18, 24 and 30 inches. For the result the graph in fig. 3 should be consulted. The Commiphoras were measured and cut at 24 inches above ground-level as is customary in clearing operations. The far greater time taken to cut down an Acacia tree than to fell Commiphora made it impracticable to include more than 50 of the former in a class as opposed to 75 of the latter. By increasing the number of the Acacias their curve might have been slightly modified—perhaps in the neighbourhood of the 38-inch point—but it is clear that that would have made no material difference to the results of the experiments. It will be noticed for each of the felling curves that the steepness increases with the circumference. This is due of course to the necessity of devoting a greater proportion of time to opening up the "cut" to accommodate the axe as the girth becomes greater, and also perhaps to the ever increasing amount of hard heart-wood.

A felling curve may, then, be considered to represent the time taken to fell trees of a single species but of various circumferences by a Shinyanga labourer of average strength and skill but fatigueless and equipped with an ever-sharp axe. From it may be read the "felling value" of any tree within the compass of the graph. Thus in the planning of the experiments that are described later it was not necessary to search for trees of a particular girth, but merely to ascertain that the girths fell within the limits of 18 and 48 inches for the Acacias and 12 and 30 inches for the Commiphoras.

3. Improvement Sought by Altering the Natives' Grip of the Ring-head Axe. Fig. 4.

The Shinyanga native ordinarily holds his own crude axe in what the European would describe as a left-handed manner, that is, when cutting on the right side he grasps the end of the handle in his right hand with the left hand nearest the blade (fig. 5). When cutting on the left side (which he does more seldom of course), he does not change hands and therefore on that side the European and native grips are identical. This left-handed method appears excessively awkward to European eyes and blows struck from the right side lack power, besides which there is often painful rubbing of the wrists. These disadvantages only become really obvious, however, when the native persists in his old type of grip when given a European tool, for he does not strike hard with his own axe but adopts rather a chopping action. Efforts have often been made in the past to persuade labourers to change their hold and adopt the European style with the European axe, so that they might swing it properly and gain the full advantage. The experiments described below were designed to discover what benefit would accrue from the considerable effort necessary to persuade the labour to change its traditional left-handed grip to the right-handed one.

In all the experiments described in this paper work started at about 8 a.m. and continued to about 3 p.m.

EXPERIMENT 1.

Native Grip versus *European Grip in felling* Acacia spirocarpa. *Fig.* 4. (*Ring-head Axes employed.*)

A gang of ten labourers was selected and employing the native grip was set to work to fell Acacia trees. Only one native cut at a time, the members of the gang being called out in strict rotation. Each worked for a period of three minutes only, just as was done when obtaining the felling values. Thus a rest period of 27 minutes elapsed between each of the three minute work periods of an individual. Meanwhile he sharpened his axe. Felling in this fashion was continued for 3½ hours. The same ten men then worked for a further 3½ hours but now holding their axes in the European manner. These two periods of 3½ hours constituted a day's work. The experiment lasted for four days. In order to discount any possible fatigue effect which might have been caused through hunger (not thirst for they had water) and handicapped the method employed in the second 3½ hour period of a day, the order of the grips was always reversed the following day.

If Experiment 1 in fig. 4 is now examined, it will be seen that there are eight columns on the left-hand side. Each represents the "value" as read from the felling curve in fig. 2, of the total number of trees cut down by a gang in half a day's ($3\frac{1}{2}$ hours') work. The hatched columns stand for the native grip, the plain ones for the European. Further to the right are two columns showing the average output of each grip, on the extreme right two more in which the winner is represented as 100 per cent. and the loser as the appropriate percentage of the winner.

Three and a half hours are 12,600 seconds and therefore if the control gang was up to the standard set by the gangs (composed of a very large number of different individuals) which defined the felling curve, its mean output should have been 12,600 seconds of work too. It was in fact 13,046, a slightly better gang. The dotted horizontal line, called the "normal line", is drawn at this 12,600 level for the sake of interest, to show the quality of the gang employed, and to act also as a convenient marker for the column representing 100 per cent.

In considering the results of this experiment it is convenient to study the left-hand columns in pairs, each pair representing a day's work. On the first day the native grip won by a very small margin, on the second the European by a greater amount, on the third day they were almost level and on the last the native grip won again. The final result was a win by the European grip but by an insignificant margin. It is apparent, then, that no immediate improvement can be expected from the mere fact of changing the grip and that effort spent in instructing short-service tribal labour to do so is a waste of time.

Experiment 2.

The Effect of instruction in the European Grip in felling Acacia spirocarpa. *Fig.* 4. (*Ring-head Axes employed.*)

The unexpected results of Experiment 1 suggested that perhaps a native found it difficult to accommodate himself to the new grip and that a course of instruction might rapidly increase the output.

The same men that took part in the previous experiment were accordingly taught for a day how to swing their axes correctly and the way the blade should cut into the wood, for a native when first given a European axe generally uses it as he is accustomed to employ his own weak weapon. The action is a chopping one and the upper cut strikes steeply downwards so that the base of the fallen stem looks like a sharpened pencil, while the stump has the scarred appearance of a butcher's chopping block. Some of the labourers seemed to respond to instruction, in others there was little improvement.

This experiment was carried out in a similar manner to Experiment 1 and lasted over a period of four days. It will be seen that the output from the European grip, now instructed, was greater than that from the same grip, uninstructed, in Experiment 1, and that therefore benefit had been derived from instruction. But, surprisingly, the increase in the control was much more. In the control the gang had held its axes native-fashion and had been told to forget the new technique of swinging the axe, &c., but far from forgetting, the natives had exploited it to the full adopting it to their own style of cutting. On each of the four days' trial the control was ahead. The control must then be regarded rather as an index of what the gang could do employing its customary native grip but equipped with the new technique of swinging the axe.

To sum up—four methods of cutting are illustrated in Experiments 1 and 2. Firstly, what the native can do with his customary grip; secondly, the effect of changing to the European grip; thirdly, the improvement effected by instruction in the European grip; and fourthly, the surprisingly good results of that instruction when applied to the native grip.

This does not mean that long practice with the European grip would not eventually turn a native into a better axeman than he could ever become using his own grip. It undoubtedly would. It does mean, however, that to change the grip, even if accompanied with a little instruction, is not sufficient to effect this.

Experiment 3.

Native Grip versus *instructed European Grip in felling* C. Fischeri. *Fig.* 4. (*Ring-head Axes employed.*)

It was now desired to find out whether the results obtained in felling the hard-wooded Acacias held for the soft-wooded Commiphoras. The men used in the previous experiments were not available so a further five were selected. Only five were required with this species of tree instead of ten because as has already been mentioned the work was so light that a 12 instead of a 27 minute rest between the three minute periods of cutting was considered sufficient. These men had had instruction in the European grip and technique of cutting and this doubtless benefited the native grip even more, as was shown in the previous experiment.

Reference to Experiment 3 in fig. 4 shows that the results were similar to those of Experiment 2, the native grip easily defeating the European. On no day was the European the better and it is interesting to note that both in this experiment and in Experiment 2 the European outputs amounted to a similar percentage of the Native, namely 87 per cent. On the other hand, it is apparent from the "normal line" that this was a very poor gang as compared with the former one.

4. Improvement Sought by Lengthening the Shaft of the Ring-head Axe. Fig. 6.

The improvement that it had been hoped to gain after instruction in holding the axe in the European fashion and using it properly not having materialized, it was thought that the poor results

PLATE I.

FIG. 1.—The types of Axes used in the experiments. (1) $2\frac{1}{2}$ lb. ring-head axe with long shaft of 36 ins. (2) $2\frac{1}{2}$ lb. ring-head axe with normal shaft of 24 ins. (3) "Good-type" native axe with head of about $1\frac{3}{4}$ lb. (4) "Medium-type" native axe with head of about $1\frac{1}{2}$ lb. (5) "Poor-type" native axe with head of about $\frac{3}{4}$ lb.

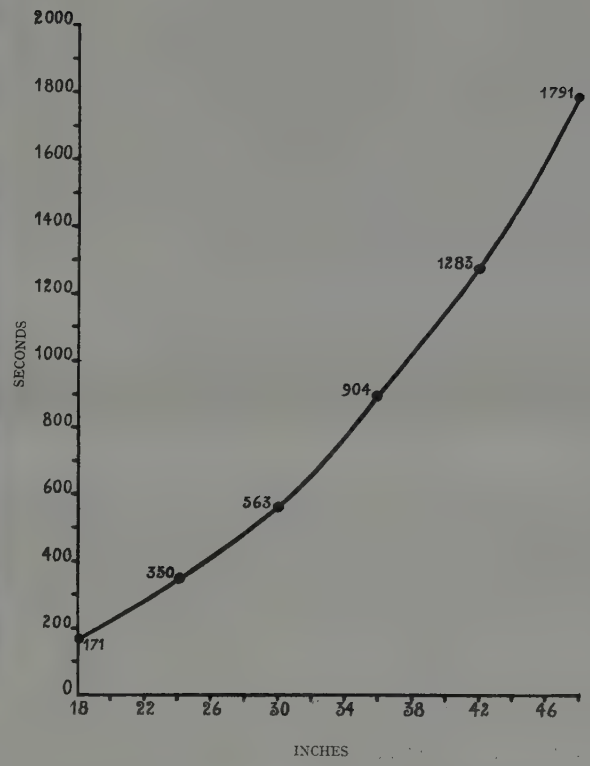

FIG. 2.- THE FELLING CURVE FOR *Acacia spirocarpa*. THE ORDINATE OF THE GRAPH INDICATES THE NUMBER OF SECONDS (ELIMINATING FATIGUE, *see* P. 155) NECESSARY TO FELL *Acacia spirocarpa* TREES OF THE CIRCUMFERENCES SHOWN BY THE ABSCISSA.

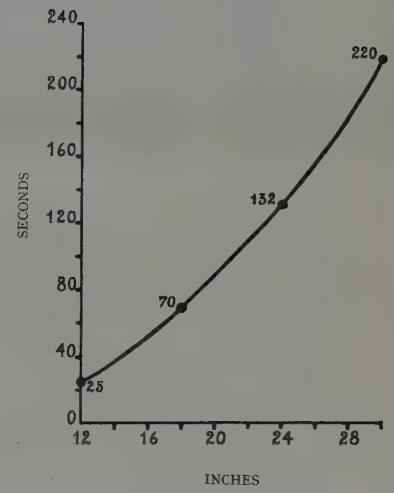

FIG. 3.- THE FELLING CURVE FOR *Commiphora Fischeri*. THE ORDINATE OF THE GRAPH INDICATES THE NUMBER OF SECONDS (ELIMINATING FATIGUE *see* P. 155) NECESSARY TO FELL *Commiphora Fischeri* TREES OF THE CIRCUMFERENCES SHOWN BY THE ABSCISSA.

PLATE II.

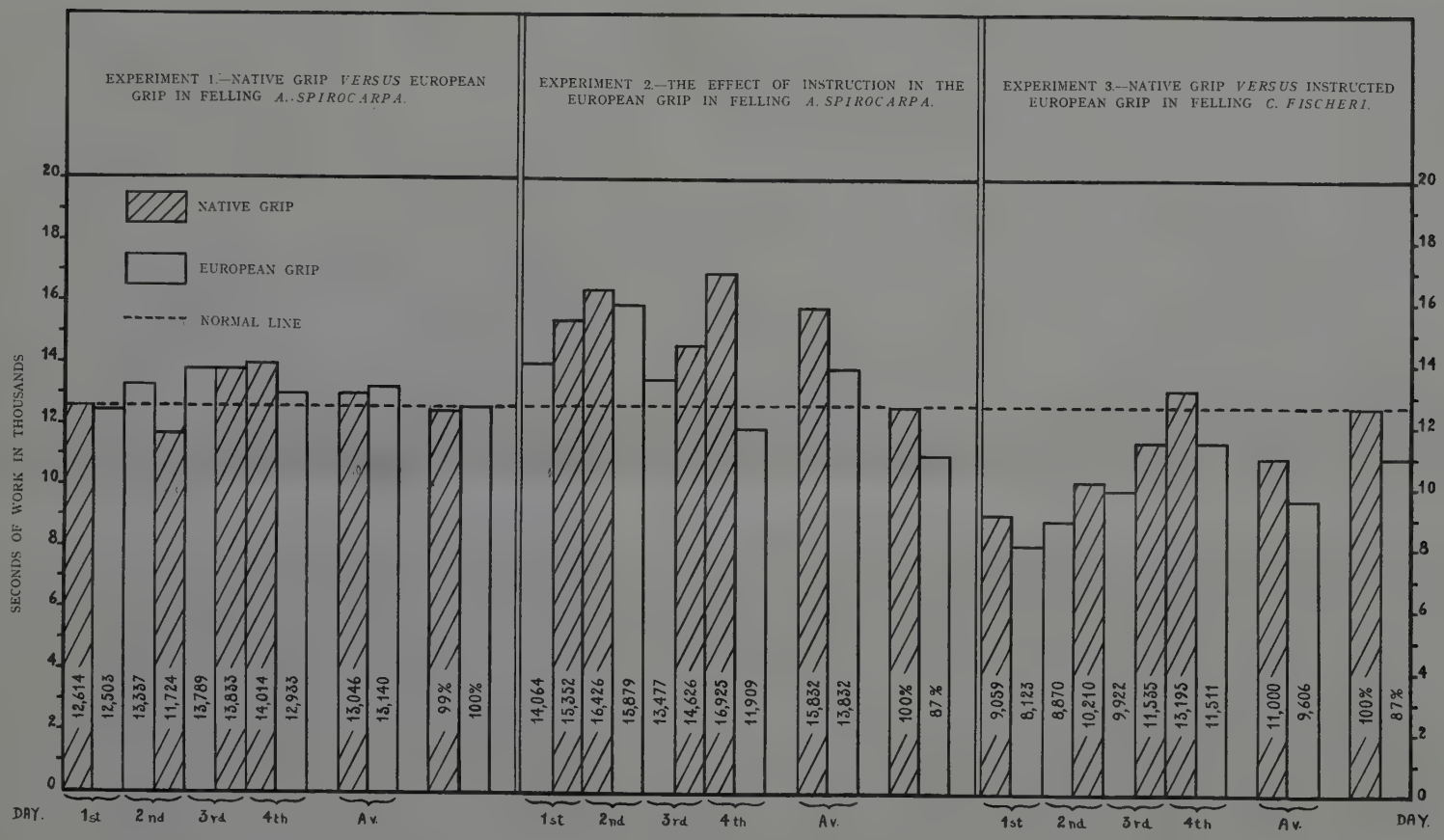

FIG. 4. IMPROVEMENT SOUGHT BY ALTERING THE NATIVES' GRIP OF THE RING-HEAD AXE.

FIG. 5.—The left-handed grip of the axe common amongst Natives.

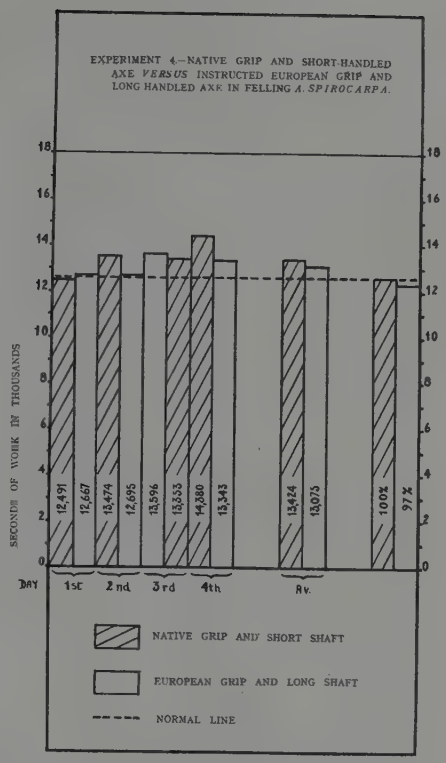

FIG. 6.—IMPROVEMENT SOUGHT BY LENGTHENING THE SHAFT OF THE RING-HEAD AXE

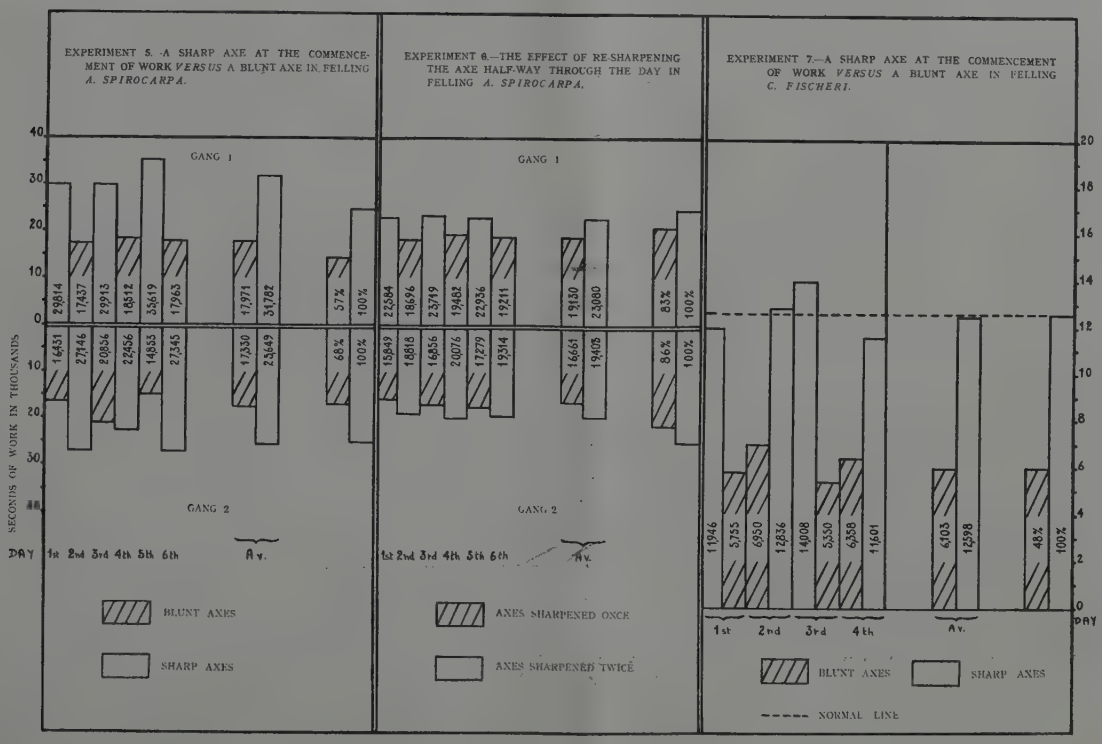

FIG. 7. THE IMPORTANCE OF A SHARP AXE

PLATE IV.

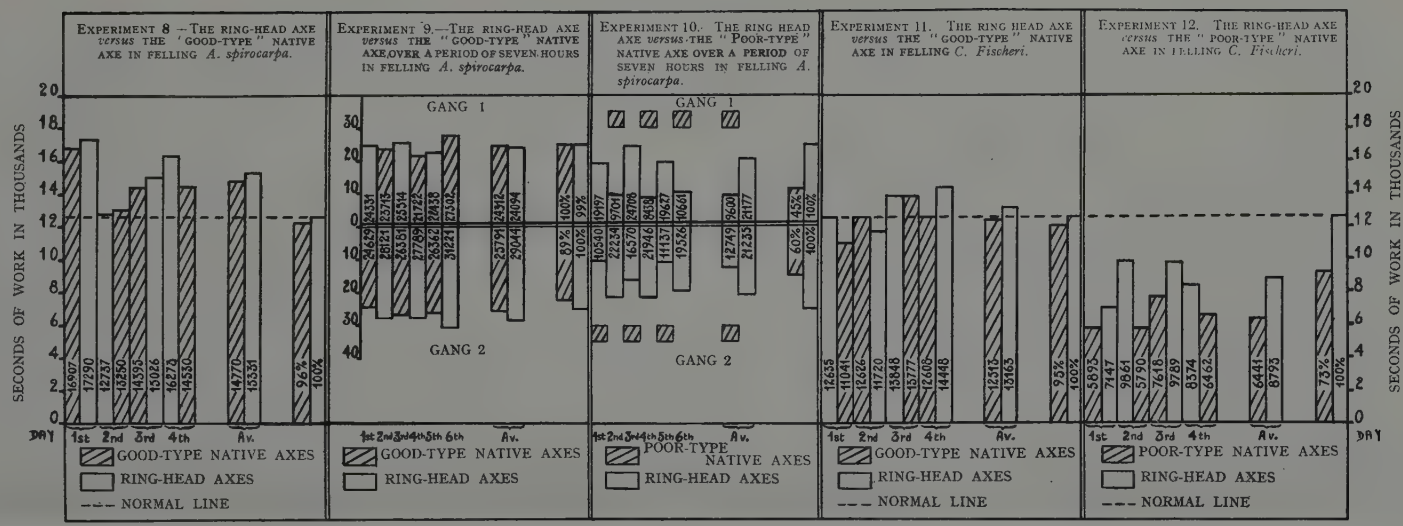

FIG. 8.—THE SUPERIORITY OF THE RING-HEAD AXE OVER NATIVE AXES

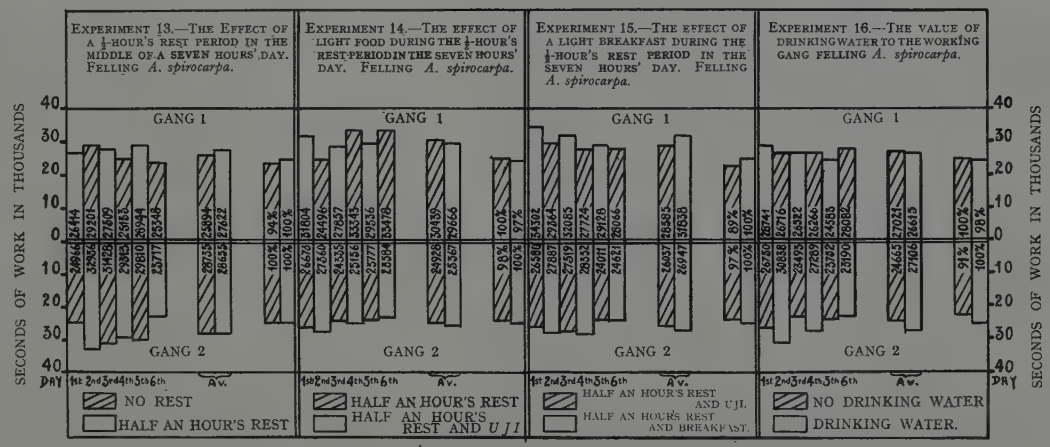

FIG. 9.—THE PROBLEM OF FATIGUE

might be due to a defect in the length of handle. The shafts normally fitted to the ring-head axe are home-made. They are cut by the raw labour from the woods, roughly shaped and average about 24 inches in length. The length is the choice of the labour and corresponds to that of the shaft of its own native axe. To the European it looks and feels too short for the best use to be made of the fairly heavy 2½ lb. head. In the experiment described below a longer handle—36 inches—was therefore tested (*see* fig. 1).

EXPERIMENT 4.

Native Grip and short-handled Axe versus *instructed European Grip and long-handled Axe in felling* Acacia spirocarpa. *Fig.* 6. (*Ring-head Axes employed.*)

The same gang of ten men was employed as in Experiments 1 and 2 and the same method was followed. In the control the European axe was held native-fashion. The control must, however, really be considered as "instructed" too because, it will be recalled, Experiment 2 indicated that once a gang was instructed in the European grip, its native grip automatically improved. Fig. 6 shows that the innovation was not a success, the long handled axes being beaten by a small margin. It is interesting to note that the output of the control was much less than in Experiment 2 and was nearly back to that of Experiment 1. About a fortnight elapsed between Experiments 1 and 2 and Experiment 4, and apparently in that time the instructed gang had forgotten much of what it had been taught.

5. The Importance of a Sharp Axe. Fig. 7.

That axes should be kept sharp is a truism and yet it is a rule that is liable to be honoured rather in the breach than in the observance unless very strict control is exercised over the labour gang.

A native cheerfully cuts with a blunt edge which eventually becomes so bad that it would seem that most of his effort must be wasted. In this section experiments are described to show just how much is lost by permitting labourers to take blunt axes to work and to discover whether any practicable improvement could be made in the existing custom at Shinyanga which is to have the axes sharp at the outset of the day's work but not to resharpen them during the course of the day.

These experiments were perforce planned on different lines to the previous ones. For these to be realistic it was necessary for the axes to become blunt at the same rate as they would had they been used by an ordinary working gang. Fatigue of the men in a labour gang, as the day wore on, would mean less intensive use of the axes and slower blunting. The only satisfactory method of simulating this was to make the experimental gangs work just like a labour gang, right through the day. The introduction of fatigue had this defect—one gang might be composed of men of poorer physique than the other; but the method described below of making one gang the control one day and the other the next day adequately met it. It met too any possibility there was of one gang being slower than the other in walking from tree to tree as they were felled. But a more serious disadvantage was attached to the new method. It was found by trial that it was impossible to give the experiments the strict European supervision to which all those hitherto described had been subjected. Trial showed that a small gang—and for practical reasons a large one could not be used—was so unaccustomed to such individual European attention that it worked itself to a standstill the first day, sulked the second and gave notice the third. The head native of the field staff—an excellent man—supervised these experiments directly, while the junior author was only in general charge. The authors were, nevertheless, satisfied that the cutters were doing their work satisfactorily under this native supervision.

EXPERIMENT 5.

A sharp Axe at the Commencement of Work versus *a blunt Axe in felling* A. spirocarpa. *Fig.* 7. (*Native Grip and ring-head Axes employed.*)

Two groups of three men each took part in this experiment. They worked daily for seven hours on end felling *A. spirocarpa* and the experiment lasted six days. One gang was armed with native-handled ring-head axes (employing the native grip) and started with their tools sharp, while the other had similar axes and used them in the same fashion but the axes were blunt, just as they might have been left after a day's work. The next day the gang with sharp axes took blunt ones and *vice versa*. Reference to fig. 7 shows clearly the scheme of the experiments. The plain columns represent the gangs with the sharp axes and the hatched those with the blunt. In this experiment (No. 5) Gang 1 had the sharp axes on the first day and Gang 2, shown directly below it, had the blunt axes. The next day Gang 1 had the blunt axes and Gang 2 the sharp. In studying the figure, the output of Gang 1 on any day should be compared with the output of the same gang on any other day and not with Gang 2. Thus on the 1st day Gang 1 scored 29,814 with its sharp axes and this may be compared directly with the total of 17,437 it scored with blunt axes on the following day. A comparison should not be made with the 1st day of Gang 2, because Gang 2 was composed of natives of a different physique and energy. As before, the results have been summarised by columns showing the average of each gang working with sharp and with blunt axes. Finally the work of the blunt axes is expressed as a percentage of that of the sharp axes, 100 per cent. being given the arbitrary value of 25,200, that is, the number of seconds in seven hours.

It will be seen that every day, no matter which gang worked with the sharp axes, there was the expected larger output than from the blunt.

In one gang the blunt axes only produced 57 per cent. of the output of the sharp ones and in the other 68 per cent.

EXPERIMENT 6.

The Effect of re-sharpening the Axe half-way through the Day in felling A. spirocarpa. *Fig.* 7. (*Native Grip and ring-head Axes employed.*)

A later experiment describes how a half-hour rest-period was introduced in the middle of the seven-hours' day and the effect of this. It was thought that there might be advantage in employing part of this time to re-sharpen the axes. Accordingly in this experiment in which *A. spirocarpa* trees were again felled with initially sharp axes and both gangs had their half-hour rest, one re-sharpened its axes while the other left them as they were. Fig. 7 shows that a substantial advantage was gained from the re-sharpened axes and this would not have entirely disappeared, even had the control gangs worked right through the day and gone without their half-hour rest. This experiment cannot be compared directly with Experiment 5 because it was unfortunately necessary to use different natives for it. They were obviously much inferior to the gangs working in Experiment 5, but it must not be forgotten that they only had 6½ hours in which to work instead of 7.

EXPERIMENT 7.

A sharp Axe at the Commencement of Work versus *a blunt Axe in felling* C. Fischeri. *Fig.* 7. (*Native Grip and ring-head Axes employed.*)

C. Fischeri has such a soft-wood that it seemed probable that the sharpness of the axes would play a much smaller part than in felling *A. spirocarpa*. It was impracticable to stage an experiment on the lines of Experiments 5 and 6 for an enormous number of this rapidly felled species of tree would have been required for the experiment. A return was made, therefore, to the method previously employed, the gang consisting of five men, each cutting for a period of three minutes. During one half of the day blunt axes were employed, in the other half the axes were sharp. Referring to fig. 7, the plain column shows the output with the sharp axes and the hatched that with the blunt. It will be seen that on every day the sharp axes beat the blunt by a very large margin. At first glance it would seem surprising that in the final result in this experiment with soft-wooded trees the blunt axes cut only 48 per cent. of that cut by the sharp, while in Experiment 5 with hard-wooded trees, when the difference might have been expected to have been greater, the figures were as high as 57 and 68 per cent. The reason certainly lies in the fact that in Experiment 7 the sharp axes were continually being re-sharpened after each three minutes' cutting (a necessary part of the technique) while in Experiment 5 the sharp axes became blunter as the day wore on, and therefore a fair comparison can hardly be drawn.

6. The Superiority of the Ring-head Axe over Native Axes. Fig. 8.

According to the tribe that manufactures them and the use for which they have been made, native axes can be placed in three classes, the good-type, the medium and the poor. Fig. 1 illustrates these three types. The blade, which is of untempered iron, has a very keen edge and is attached to the handle by a spike driven through a hole made with a piece of hot iron. This is a source of weakness, for a hard blow is liable to drive the spike further in and to cause a split in the wood; therefore, as has been explained, a chopping action is adopted. Nevertheless the natives become very adept in its use. Due to shortage of ring-head axes it is sometimes necessary for the men to bring their own axes to tribal clearings and on such occasions it is human and not unnatural that the best are often left behind. In the series of experiments described below an attempt has been made to discover how these different types of native axes compare with the ring-head axe.

EXPERIMENT 8.

The Ring-head Axe versus *the "Good-type" Native Axe in felling* A. spirocarpa. *Fig.* 1. (*Native Grip.*)

Reference to Experiment 8, fig. 8, shows that the first method of experiment was used, each cutter working for three minutes. The native axe came through the ordeal in a surprisingly successful manner and actually defeated the ring-head axe on one occasion. In the final result the output of the native axe amounted to the excellent average of 96 per cent. of that of the ring-head. The reason for this success is thought to be the deftness with which the native handles his traditional weapon and above all the fact that the axes were continually being re-sharpened, thus annulling the handicap of the soft metal of which they were made. Accordingly in the next experiment, the second experimental method was adopted, and the axes subjected to a test of seven hours' continued use. This was expected to reveal the weaknesses of soft metal and delicate shaft-fitting of the native axes.

EXPERIMENT 9.

The Ring-head Axe versus *the "Good-type" Native Axe over a Period of Seven Hours in felling* A. spirocarpa. *Fig.* 8. (*Native Grip.*)

This test was carried out over six days and the excellence of good-type native axes in expert hands was once more demonstrated. On three occasions the native axes won and it is interesting to note that on each it was Gang 2 that was using them. Either Gang 2 excelled with the native axe or Gang 1 persistently handled the ring-head axe poorly. In the final outcome the average of Gang 1 with the native axe was very slightly higher than with the ring-head and the average of Gang 2 was 89 per cent. that on the ring-head. It is remarkable that after this gruelling test of continuous use, no shafts of the native axes were either split or broken.

From the results of Experiments 8 and 9 it can only be concluded, then, that good-type native axes are almost the equal of the ring-head type even when employed on such hard-wooded trees as *A. spirocarpa*. On reflection the authors, from practical experience in the field, are prepared to accept the results.

EXPERIMENT 10.

The Ring-head Axe versus *the "Poor-type" Native Axe over a Period of Seven Hours in felling* A. spirocarpa. *Fig.* 8. (*Native Grip.*)

This experiment is the counterpart to Experiment 9, poor-type native axes being tested instead of good-type. In fig. 8 it will be seen that they made a very poor showing against the ring-head axes, but even so their full inefficiency is not brought out. There were frequent cases of shafts splitting and blades bending so that they had to be replaced and to that extent the figure shows the results with the poor-type native axes in a much too favourable light.

From this experiment it is possible to judge the loss in output that may result from tribal labourers using their own native axes. In practice there is yet a further disadvantage. Armed with a light native axe, the labourer is tempted to avoid cutting the tree low down—as he should—where the stem is thick and hard and resorts instead to mere branch lopping with the result that the clearing is badly made and inefficient unless very closely supervised.

EXPERIMENT 11.

The Ring-head Axe versus *the "Good-type" Native Axe in felling* C. Fischeri. *Fig.* 8. (*Native Grip.*)

This experiment may be compared directly with Experiment 8 in which the good-type native axes were used in felling the hard-wooded *A. spirocarpa* trees. Their success in that experiment would lead one to expect a similar success with the soft-wooded *C. Fischeri*, and so it was, for it will be seen that the average output from the good-type native axes was as high as 95 per cent. of that from the ring-head axes.

EXPERIMENT 12.

The Ring-head Axe versus *the "Poor-type" Native Axe in felling* C. Fischeri. *Fig.* 8. (*Native Grip.*)

It would have been preferable to have carried out this experiment over a six days' test so that a direct comparison might have been made with Experiment 10 in which hard-wooded Acacias were felled and the conditions approached more nearly those obtaining in the field. This was impossible, however, owing to the enormous number of the rapidly felled *C. Fischeri* trees that would have been required. In examining the results, which show that the poor-type native axes gave on the average an output 73 per cent. of that obtained with the ring-head axes, it must be borne in mind, firstly, that the former were continually being re-sharpened (necessary in the technique of this method) and that they undoubtedly gained more from this than the tempered ring-head axes, and secondly, that over a six days' test many shafts of the native axes would have been split.

It will be noticed that the half-day outputs are all much smaller in this experiment than in the preceding one. This is due to the fact that the gang employed was a different and apparently an exceedingly poor one.

7. The Problem of Fatigue. Fig. 9.

The experiments described below are an attempt to study the effect of fatigue on output and discover remedies which might lessen the former and consequently affect the latter favourably.

In different parts of Africa different conventions rule as to the length of hours the native labourers are expected to work and what rest-periods and what food they should receive during the working day. In South Africa the senior author has often seen a break of half an hour given for breakfast and another of one hour (or two in the hot season) at midday for luncheon. There, however, the labourer was working from approximately sunrise to sunset.

In Shinyanga it has been the custom for the native to work his seven hours—which make up his day's work—without a break and without food, but with water when the heat makes it necessary. On the face of it, such a custom looks absurd and inhuman, and it might be supposed that almost any system would give better results and be more popular than this—and yet in practice of course it is neither unpopular nor unproductive.

Where food has been supplied in these experiments, it has been given, not with the long range purpose of gradually improving the physique of the natives and indirectly their output, but with the immediate object of strengthening them during a long stretch of work to which they have often come with an almost empty stomach.

In all the following experiments the ring-head axe was used with the normal 24 inch shaft and held in the native fashion.

EXPERIMENT 13.

The Effect of a ½-hour's Rest-period in the Middle of a Seven Hours' Day. Felling A. spirocarpa. *Fig.* 9.

In this, the first experiment of the series, it was decided to test the effect of a rest-period of half an hour given at an arbitrary point—three and a half hours after the commencement of work. This meant that the total time spent in felling amounted to six and a half hours only, not seven hours.

Before the commencement of this experiment the natives participating were carefully informed of its object, so that the psychological effect of a promised rest might play its part. That introduced a disturbing factor but the experiment was intended to be realistic, for were the principle applied to an ordinary gang working in the field it would be given just such information with the threat that the old system would be revived were the output to fall considerably.

Reference to Experiment 13, fig. 9, shows that the gangs that had the half hour's rest-period did practically no more work than those that had no rest. For each hour they worked they produced so little more that they could barely make up for the loss of half an hour in total time. On the other hand the view might be taken that it was more surprising that nothing was lost.

EXPERIMENT 14.

The Effect of Light Food during the ½-hour's Rest-period in the Seven Hours' Day. Felling A. spirocarpa. *Fig.* 9.

It was thought that the introduction of light food during the half hour's rest-period might increase the value of the rest. Accordingly a ration of "uji"*, a native gruel, was issued. The gangs which partook of it were enthusiastic supporters of the innovation, but in spite of its popularity the issue of "uji" had no effect at all on the output as will be seen from Experiment 14, fig. 9. It should be noted that in this experiment the control gang also had its half hour's rest, so that the only difference between the two gangs was the supply of "uji".

EXPERIMENT 15.

The Effect of a Light Breakfast during the ½-hour's Rest-period in the Seven Hours' Day. Felling A. spirocarpa. *Fig.* 9.

On enquiry it was found that many of the labourers who slept at home and started for work very early in the morning had had what was undoubtedly a very inadequate breakfast. After consultation with them, then, it was decided to give the experimental gang a light breakfast of "ugari" and sugar during a half hour's rest-period two and a half hours after work had commenced. The control gang had its half hour's rest three and a half hours after the commencement of work, as before, and was supplied with "uji". Reference to fig. 9 shows little difference between the two in performance, but what advantage there was lay with the breakfast gang.

* The junior author, who has a wide knowledge of native customs, and preferences as regards food, is responsible for the choice of these two meals.

"Uji" is the Kiswahili name for a gruel made from "uwele" (bullrush millet) flour. This was chosen as the flour itself is slightly sweet and the gruel from it palatable without any additions. The gruel is eagerly eaten by natives desirous of a liquid but sustaining refreshment during work in the heat of the day. A ration was issued to each man that corresponded to about 3 oz. of the dry flour.

"Ugari" is the name for a stiff porridge made from white sorghum flour. This forms a much more substantial meal than the sloppy "uji". It is commonly eaten with a syrup of "sukari guru", *i.e.* native sugar. "Ugari" was chosen because it has the double virtue of being easily obtainable and universally liked. Each native was given a ration equivalent to ½ lb. of the dry flour and about 1¼ oz. of sugar.

EXPERIMENT 16.

The Value of Drinking-water to the working Gang. Felling A. spirocarpa. *Fig.* 9.

Natives are accustomed to go without drinking-water for long periods even when working hard in the sun and it has sometimes been an open question whether water should be supplied or not. There are times of the year of course when the conditions are such that water must be supplied, just as there are others when there is not the slightest necessity. To transport and supply drinking-water to a gang of anything up to several hundred natives is no light task and not one that should be undertaken without sufficient cause. Besides the actual time spent in drinking, the interruption results in a break in the swing of the work as the authors know from practical experience and this appreciably affects the day's output.

This experiment was carried out in August, when conditions are beginning to become trying, the average screen reading for the hours of work being 76.9 for the month. Evaporation from a Livingston atmometer averaged 81.9 ccs. daily (24 hrs.) for that month. It was just the time when there is doubt as to whether water should be supplied or not. Later on much severer conditions are experienced.

When water was given to the gang it was done so sparingly, no man taking more than three drinks during his seven hours' work. Some individuals preferred to take very little indeed. Reference to fig. 9 shows no significant difference between those gangs drinking water and those doing without and it should be noted that the latter did not complain or show distress and completed their work quite happily.

8. Summary.

(*a*) The object of the experiments described in this paper was to discover means of increasing the efficiency of the labour, both voluntary and paid, that is employed in making anti-tsetse clearings.

(*b*) A method was evolved of assessing the "felling value" of *Acacia spirocarpa* trees of various circumferences, representative of the hard-wooded trees found in the Shinyanga savanna, and of *Commiphora Fischeri* trees, representative of the soft-wooded. These formed the raw material of the experiments.

(*c*) Attempts have been made in the past to persuade the native to relinquish his traditional left-handed grip of the axe and adopt the European right-handed style. It was now shown, however, that in felling *Acacia spirocarpa* no immediate gain could be expected from such a change.

(*d*) It was thought that a gain would become apparent were the native put through a short course of instruction in swinging the axe to teach him how properly to exploit this new right-handed grip. A considerable gain, in felling *A. spirocarpa*, was achieved but the gangs using the old left-handed grip showed an even greater improvement.

In other words, the old grip plus instruction gave better results than the new grip plus instruction.

(*e*) A similar experiment was done with *C. Fischeri* with similar results.

(*f*) It seemed that the failure of the right-handed grip to defeat the left-handed grip might lie in the shortness of the home-made shaft of the axe with consequent failure to take a full swing. A longer shaft was accordingly fitted, but no benefit was derived from this in felling *A. spirocarpa*.

(*g*) Axes sharp at the commencement of the work gave far better results than those blunt, in felling both *A. spirocarpa* and *C. Fischeri*.

(*h*) The effect of re-sharpening the axes half-way through the day during a half-hour's rest was tested. In felling *A. spirocarpa*, the gang that employed its leisure in re-sharpening its axes gained a substantial advantage, and even had the control gang worked straight through without a rest it would not have destroyed this completely.

(*i*) In felling *A. spirocarpa* and *C. Fischeri* the "good-type" native axe proved itself the equal of the European ring-head axe, even in continual use over a period of seven hours.

(*j*) The "poor-type" native axe, however, was greatly inferior to the ring-head pattern in felling both *A. spirocarpa* and *C. Fischeri*.

(*k*) No significant advantage was gained from introducing a half hour's rest-period in the middle of the day's work. On the other hand nothing was lost.

(*l*) No advantage was gained from supplying light food or breakfast during the rest-period, or by supplying drinking-water to the gang, at the time of the year when these experiments were carried out.

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THE RÔLE OF MANGANESE AND COBALT IN PLANTS AND ANIMALS.

[*The following note is abstracted mainly from articles by Dr. Ethel Browning, which appeared in "Science Progress," Oct.,* 1937, *Vol. XXXII, No.* 126, pp. 276-289, *and by Messrs. Marston, Lines, Thomas and McDonald, which was published in "Nature"* 1938, 141, pp. 398-400.—Editor.]

Manganese.

THIS element is universally distributed in *plants*, and appears to be essential to growth, though its mode of action is not yet fully understood. It may be the active principle of oxidases, which are enzymes controlling oxygen metabolism. The greatest amounts of manganese occur in the reproductive organs of plants (the ovules of flowers and the "germ" of seeds), and in young, rather than old leaves. There may be a relationship between Vitamin B and manganese. The highest average manganese content of vegetable foodstuffs is about 200 parts per million of their weight.

In *animals*, manganese is a normal constituent of practically all tissues, though much lesser in amount than in plant tissues. It occurs in milk, blood, bile, urine, gall-stones and teeth, but whether it is indispensable therein has been questioned. As in the case of plant tissues, manganese appears to function in the animal as a catalyst or an activator of vital enzymatic reactions, rather than as a special stimulant of any particular tissue, such as embryonic tissues, ovarian and testicular tissues, the anterior lobe of the pituitary gland, or mammary tissue. Liver tissue is richest in manganese (about 3 parts per million of fresh liver), with kidney and pancreas next. The manganese content of the blood increases during the first few hours after it has been taken by the mouth, but its high rate of elimination soon lowers its level. Very little manganese is eliminated in the urine; it is largely excreted through the colon, by the faeces and the bile. Unlike copper, manganese is able to pass through the placenta to the developing embryo. It appears to be essential to the physiological development of children, whose diet should therefore contain milk, meat, eggs, tomatoes, orange-juice, cod-liver oil, whole cereal grains, pineapple, blueberries and beets, all of which are rich in manganese.

Experiments with highly purified diets, containing all other essential elements and vitamins, indicate that, while young animals can grow to maturity without manganese, either the reproductive activities of parents are disturbed so that they are unable to suckle their young properly, or the young are born with a congenital debility which makes them unable to take enough nourishment. There may thus be some connection between manganese and a pituitary hormone essential for the functioning of the generative organs in the male and the mammary tissue in the female. On the other hand, deprivation of manganese may prevent the embryo growing

normally. In either case, the effects could be explained by the absence of catalytic action of manganese in the vital oxidation-reduction, activities of both adults and embryos.

Young animals fed on milk alone are liable to develop a form of anaemia due to diminished numbers of red corpuscles and low haemoglobin values. This anaemia may be cured by iron, but the improvement is not permanent unless copper is also supplied. Whether manganese might exert a similar effect to copper, however, has not yet been definitely proved by experiment, though in some rare instances it apparently might so function.

Manganese increases the oxygenation of carbohydrates and the oxidising activity of laccase, and may thus augment or even account for the function of Vitamin B, whose distribution closely corresponds with that of manganese.

Cobalt.

Like manganese, cobalt is widespread in plants and animals, though in very minute quantities. In *plants*, the leaves are generally richest in cobalt and the seeds come next, but the quantity present seldom exceeds 0.3 parts per million.

In *animals*, all tissues except fat and egg-white contain cobalt, the greatest amounts occurring in liver, pancreas, spleen, vertebrae and ribs. The human spleen may contain 0.5 p.p.m.of cobalt but the blood contains only 0.001 p.p.m. Cobalt fed by the mouth is excreted in the urine; storage does not apparently take place in any particular organ.

Unlike iron and manganese, cobalt does not appear to be a true catalyst, though at one time it was suspected that it might be the "co-ferment" of insulin secreted by the pancreas. During recent studies of nutritional anaemia produced by a milk diet, the very important discovery was made that *cobalt greatly increases the number of red corpuscles in the blood*, and that the effect is a direct or indirect stimulation of bone-marrow. In this connection, copper was found also to be necessary as a supplement to cobalt, while manganese may help as an auxiliary by stabilising the effect of cobalt and decreasing its toxicity.

Cobalt has recently been suggested to be a stimulant of the sympathetic nervous system, since it produces a dilation of the peripheral blood vessels of the face, and a fall in blood pressure when injected into the blood stream.

The physiological effects of cobalt have come into considerable prominence in the past few years, because of its possible connection with the problems of "bush-sickness" of sheep in New Zealand, "enzootic marasmus" in Western Australia, "pine" in the Cheviots and Inner Hebrides of Scotland, "nakuruitis" in Kenya, "salt sickness" in Florida and "coast disease" in Southern Australia.

According to a recent account of the rôle of cobalt and copper in ruminant nutrition by Messrs. Marston, Lines, Thomas and McDonald, of the University of Adelaide, South Australia, the apparently essential nature of cobalt was first suggested during an investigation of "coast disease", and announced at Adelaide in January 1935. Symptoms of lethargy, wasting and anaemia in ruminants which had been confined to certain areas of pasturage, and their rapid alleviation when the flocks were moved to another type of country, have been recognised for many years, even as far back as the early nineteenth century. New Zealand "bush sickness" was first actually reported in 1806, and again in 1900. It occurs in sheep that are grazed on lands whose soils have been derived from geologically-recent volcanic ash, and was first thought to be due to iron deficiency. Certain iron salts and the mineral limonite were found to benefit the affected flocks when they were dosed with these materials.

Similarly, "enzootic marasmus" affecting sheep and cattle grazed over ferruginous sandy-loams in Western Australia, was also found to be alleviated by limonite treatment, though *pure* iron salts were ineffective.

Meanwhile, investigations of "coast disease" affecting sheep confined to calcareous shelly-sand pastures in South Australia, showed also that purified iron salts failed to arrest the malady, whereas a complex salt mixture, containing cobalt, proved capable of maintaining health.

The key to these problems was furnished, however, by the discovery (alluded to above) that cobalt therapy could completely cure anaemia in rats (Waltner, 1929). The implication that sheep suffering from "coast disease" might react in like manner to cobalt was amply confirmed by the Adelaide investigators, and later, similar response to cobalt treatment was obtained by the West Australian workers in the case of "enzootic marasmus". Following these discoveries, the New Zealand investigators demonstrated in 1936 that cobalt supplements were completely effective as a preventative and cure of "bush sickness", and the treatment has since been widely applied with great success in New Zealand. It still remains to be demonstrated, however, that cobalt deficiency is the underlying cause of the three other maladies, namely "pine", "nakuruitis" and "salt sickness", though recent analyses of soils and forages in England have shown that some Dartmoor pasturage grasses on which sheep suffer a form of "pining", contain very little cobalt (0.2 p.p.m.), while healthy change "pastures" are much richer (0.5 p.p.m.). The corresponding soils also show similar differences. (J. B. E. Patterson, *Nature*, 1937, 140, p. 363.)

In the case of "coast disease", it has now also been found that minute amounts of copper are essential in maintaining cobalt-treated animals in good health, so that the physiological importance of "trace elements" has come to be completely recognised, and further fundamental discoveries in this field may be expected.

F. H.

FURTHER STUDIES IN TROPICAL LAND TENURE.

By H. M. Leake.

(*Continued from Tropical Agriculture*, Vol. XV, No. 6, p. 132.)

II.—THE WEST INDIES.

The West Indies form a group of Colonies which includes some of the longest established possessions of the Empire. Though the dates of the various acquisitions range over a long period, a matter of over two centuries, the latest antedates the abolition of slavery. The land system is coloured by this fact; throughout, plantations are found and these, originally, were personal possessions. With the abolition of slavery, a collateral peasant system grew up which, in many instances, was reinforced by an East Indian population released from indentures and preferring to settle rather than to return to India. Other changes which time has brought about, particularly where sugar is concerned, is the conversion of the individual ownership of plantations to joint ownership by registered Companies, an accompaniment of this change being an aggregation of small, into larger units. A land tax may be enforced but it has none of the characteristics of the Indian Revenue system. That is only to be expected seeing that the major colonizing effort took place when colonists could only be attracted by an offer of free land and when the English system, which was naturally followed, had come to accept outright ownership of land. Such land taxes as exist are small and their major function is to ensure active ownership through a regular payment. Without such visible sign of ownership unauthorized "squatting" or the relinquishment without notice, with the land running to waste, would become common.

This historical foundation has led to very varied systems of tenure to a large extent dictated by the nature of the soil and climate in as far as these determine the crop. Superimposed on such questions is the nature of the processing requirements. In the case of the sugar cane particularly, modern developments of the factory since the introduction of the vacuum pan, and economic considerations arising from the large size of the unit, have led in many cases where the conditions favour cane, to company controlled aggregations of the individually held plantations, though plantations retaining their individuality and acting as feeders to central factories are still common. In the case of other crops, where large capital expenditure for processing is not involved, individually owned plantations dominate. Here the capital cost of planting up permanent crops such as cacao and coconuts and of tending these until production commences is commonly met by mortgage where personal funds are not adequate. These plantations are of varying size and merge into typical peasant holdings. The islands vary markedly in the relative importance of these roughly distinguishable types of holding; they are too numerous to be considered in detail individually and, perhaps, the clearest survey will be given by a consideration under the heads of the major crops leaving for later treatment certain more general questions.

Sugar.

Except in Barbados, where production is mainly to satisfy the somewhat specialized syrup market, cane is cultivated to produce sugar for which the unit, based on the factory, is large. In Jamaica, and even to a greater extent in Trinidad, the tendency has been, where conditions favour cane cultivation, in the direction of aggregation into large, company-owned estates, the compelling force being the need of an assured, regular and organized supply of cane if the factory is to run at maximum efficiency. This system of tenure brings to the forefront questions as to the cost of labour both directly in the cash wage and indirectly in the question of amenities. It is a relic of slavery and of the indenture system that provision of housing forms a generally recognized amenity. But, in later years, the growing self-consciousness and the desire for a higher standard of living which is characteristic of the labouring classes throughout the world and arises from the spread of education and from the newer methods of dissemination of news and ideas, have not passed by plantation labour. If that labour has remained comparatively quiescent, it is because agricultural employment forms the dominant outlet for labour while the slump has, with delightful impartiality, hit all forms of agricultural production and few openings for more profitable employment exist to provide invidious comparisons. The potentialities for unrest are there and they affect both the company-owned and the smaller, individually-owned plantations. It is unnecessary to detail the conditions of the sugar market; in face of an excess production which has forced international regulation of supplies, and in face of a potential increase of supply capable of immediate development and adequate to meet any increase in consumption, it is difficult to see how even the reasonable demands of labour are to be met.

That is the problem for which a solution is being sought and the solution of which is essential to the survival of the plantation industry. It is being sought in two ways. Better cultivation in the broadest sense of that term is leading to larger yields from the unit area cultivated, increases of yields which more than cover their cost of production. In another direction, greater use is being made of the latest developments of the power unit in its adaptations to the various cultural operations. Here it is a question of balancing wages against running costs and depreciation on the capital cost of equipment. From the tenure point of view the pressure here is in the direction of a greater aggregation of units.

Such a new orientation, however, is a slow process and meanwhile the depression in the industry has been devastating. In several cases relief has been provided in the form of loans directly or indirectly backed by Government. In Jamaica, Government aid, backed by a certain

amount of control, has proceeded furthest. In 1921 a Sugar Industry Aid Law (10 of 1921) established a Sugar Industry Aid Board and authorized a loan of £400,000 to assist owners of land. Supplementary Laws (3 of 1922, 24 of 1923 and 20 of 1924) authorized further loans for the same purpose and the re-issue of the sums received in repayment. A later Law with the same title (26 of 1929) authorized loans when the price fell below £16 per ton f.o.b. to the amount of £2 per ton or of the difference between the actual price and £16, whichever is less, permitted import only under licence, fixed an export quota of 80 per cent. of the sugar produced, regulated the retail price and constituted a Sugar Control Board. Loans under this Law were subject to the condition that the borrower should join in, accept or assent to a common agreement providing for the appointment of a Sugar Manufacturers' Board and to the export of 80 per cent. of the sugar manufactured in 1929-30 and thereafter such proportion as the Board should decide. A further Law (13 of 1931) appropriated an additional sum for distribution when the price of sugar fell below £14 per ton and in other respects followed the terms of the 1929 Law. This Law and a Sugar Prices Control Law (13 of 1932) were repealed by the Sugar Industries Control Law (31 of 1933) which was of the nature of a consolidating Law. Lastly, the Sugar Industry Control Law (43 of 1937), passed primarily to implement the international control agreement of that year, introduced a detailed control throughout the industry. Under it the island quota and quotas for export, local consumption and reserve are fixed by Government, a Sugar Control Board instituted and detailed conditions laid down for the licencing of cane farmers and for the price to be paid for canes.

In British Guiana the Sugar Industry Assistance Ordinance (1 of 1922) authorized a Government guarantee for private loans to estates up to $10 per ton of sugar produced and the Sugar (Regulation of Prices) Ordinance (15 of 1931) regulated the maximum prices for the local market. In Trinidad the Sugar Relief Ordinance (15 of 1930) authorized loans to owners of lands cultivated in cane at the rate of £2 per ton exported on condition that no reduction is made in the rate of wages paid to labour, that cane shall be cultivated and sugar made in 1931 and that 12*s.* per ton be paid for farmers' cane with 6*d.* per ton less for each ten shillings that the f.o.b. price of sugar falls below £10 10*s.* per ton.

These are aids to the industry as a body and mainly affect the estates or plantations. But the plantation is not the only unit on which cane is grown. In St. Lucia it is grown on a métayer system; the factory claims one-third of the crop in return for the provision of seed cane and for financing the growth of the crop, and purchases the balance. In all islands, farmers cultivate cane on holdings of varying sizes down to peasant holdings for sale to the factory. But the most highly organized production of cane subsidiary to that of the estate occurs under the cane farming system in Trinidad. The early history of that system has been given in the previous series of these Studies. In 1926 the recommendations of a Committee* concerning payments to be made to cane farmers was adopted. This fixed a sliding scale based on 5 per cent. of the average f.o.b. price for grey crystals, Port-of-Spain, 1st January to 30th June for the year in question. This scale gave a price for canes of $2.88 per ton when the price of sugar was £12 per ton, the lowest price then contemplated as being likely. A further "gentleman's agreement" included in the recommendations recognized $2.88 as a minimum price which factory owners agreed to maintain as long as possible and, as noted above, the Sugar Relief Ordinance of 1930 confirmed this minimum price by making its acceptance a condition of the receipt of a loan. The low prices reached later (under £3 per ton) forced a reconsideration of this minimum and, in 1934, the sum of 11*s.* per ton was fixed. The whole position of cane farming was regularized by the Cane Farming Control Ordinance (13 of 1937) as part of the regulations to implement the restrictions on production following the laying down of quotas. The control exercised by this Ordinance is somewhat detailed. It fixed the amount of farmers' canes to be accepted as not less than in the same ratio to the total amount ground as in the higher of the two previous years, enforced contracts, laid down their terms, fixed the purchase price at $2.64 (11*s.*) per ton when the f.o.b. price of sugar was $48 or less with increments of not less than 12 cents for each $2.40 over that f.o.b. price, appointed an Arbitration Board with the Director of Agriculture as Chairman and made decisions of the Board enforceable in the Supreme Court. These Ordinances, however, leave aside some of the major problems of the cane farming system. These are agricultural and are summed up in the ultimate fact that the yield obtained by cane farmers as well as the quality of the canes are not equal to those obtained on estates. The Preliminary Report on the Cane Farming Industry† estimates the difference as 6 tons per acre (24 tons to 30 tons) for plant canes, 4 tons (16 tons to 20 tons) for 1st ratoons and some 2 tons for later ratoons. The reasons for this difference are various but intimately bound up with the absence of technical control and the difficulty of organizing this under a peasantry nearly 80 per cent. of which is not a tenantry of the estates.

Cacao.

If depression has been severe in the sugar industry, it has been no less so in the case of cacao. Cacao has been grown in the West Indies from early times but cultivation reached its fullest development from about the seventies of last century till the end of the war. It forms a major crop in Trinidad and Grenada and, during that period, became the most important single agricultural export of Trinidad. It is unnecessary to describe the industry in detail since a close investigation covering the latter island has been made by Shephard and the results published in a series of articles.‡ The catastrophic fall in

* Council Paper 70 (1926). † Council Paper 84 (1933).
‡ *Tropical Agriculture* 9 (1932), 13 (1936), 14 (1937).

prices following the war and again from 1930 onwards, has been accompanied by a sharp decline in the quantity of the harvest. From over 75 million lb. in the peak year, 1921, exports fell to an average of 57 million lb. in 1927-29 and an average of 33 million lb. in 1934-36 with a lowest figure of 26.8 million lb. in 1934. This fall in production is due, in part, to a reduction of acreage but other factors also had their influence. The enforced economy resulting from low prices took the form of reduced cultivation which had its effect on the trees and, unfortunately, in 1928, the witchbroom disease made its appearance. But, perhaps, more important than these, was a general ageing of the fields. With a peak yield at the approximate age of 25 years, an increasing proportion of the area under cacao is becoming over mature since the cessation of planting. But, behind these agricultural aspects, is the financial organization of the industry.

The processing of cacao requires small capital outlay in comparison with sugar, but it is a delicate process, as are all fermentative processes, requiring considerable skill if a high grade product of uniform quality is to result. There has not been the same pressure towards aggregation into large units. These have remained relatively small and, in 1932, no less than 62 per cent. of the estates, covering some 17.5 per cent. of the 209,000 acres planted to cacao, were under 10 acres in extent while 93 per cent., covering some 45 per cent. of that area, were under 50 acres. The total area must have totalled some quarter million acres during the boom period and much of the capital for this development was provided on mortgage. As commonly the case when an industry appears to be firmly established, witness the indigo industry of northern India in the latter half of last century, mortgagees have no desire to foreclose and a too sudden reversal of fortune prevents them from doing so without disastrous results. That was the position of the cacao industry when overtaken by the slump which followed the war.

The Government was early forced to intervene and, under the Agricultural Relief Ordinance (66 of 1921) authority was taken to advance public moneys to owners of plantations and the administration under the Ordinance was vested in an Agricultural Relief Committee. This Ordinance is of general application to any plantation but its main concern was the cacao industry and its object the restriction of foreclosures. The Agricultural Bank Ordinance (12 of 1924), establishing an Agricultural Bank of Trinidad and Tobago was a further step in the same direction. It authorized the formation of a Bank to be financed by loans which were to be devoted to the development, maintenance and improvement of estates and to the discharge of liabilities so incurred. Administration was to be by a Board of Management appointed by the Governor. In 1926 funds were provided by the Local Loans Ordinance (20 of 1926) which authorized Government to take up debentures to the limit of £250,000.

The further slump in 1930 led to additional Governmental assistance. The Cocoa Relief Ordinance (36 of 1930) repealed the Ordinance of 1921 and specified more particularly the objects for which loans might be given, including therein payment of interest on encumbrances. By the Cocoa Relief (Amendment) Ordinance (21 of 1931) loans were forbidden when the property, under normal conditions, had an uneconomic value or when the owner, in the opinion of the Board, was in a position to meet the expenses. A further Amending Ordinance (24 of 1932) defined the purposes for which loans might be granted still more closely. With the prolongation of the depression, further aid was given by the Cocoa Subsidy (Special Taxation) Ordinance (36 of 1935) which imposed a levy equal to 10 per cent. of the income tax part of which was ear-marked to meet the charges on a loan of $2.5 million authorized under the Cocoa Subsidy Loan Ordinance (38 of 1935).

But the value of the cacao crop is not merely a question of weight. The product is processed for the market by fermentation and this, as has been stated, is a delicate treatment by the ill regulation of which quality may be readily destroyed. Though Trinidad cacao has always commanded a premium in the world market for its best qualities, much that is exported falls below that best through faulty processing and it would appear that the average premium is less than was formerly the case. Considerable financial advantage would accrue if the average quality of the crop could be raised. There arises here that difficult problem of the control of a delicate process among a large number of independent and small producers. It is a problem that has to be faced under all systems of tenure which are based on peasantry. As early as 1905 a Cacao Planters' Association was organized by 26 estates with the object of grading, bulking and disposing of the joint crop. In 1915 the Association was registered as a Limited Liability Company. Progress was slow, however, and operations were extended only in 1936 to include voluntary inspection by a Cacao Inspection Board. In part this slow progress was due to the fact that members of the Association who produced high grade cacao did not get the premium received, this being merged in the common fund. The limitation of the premium to producers of high grade cacao only was first introduced in 1931. Since 1930 further progress has been made in the opening of co-operative and Government controlled fermentaries with membership of the Association.

Grenada is another island in which cacao forms an important industry. Here no specific steps appear to have been taken to meet the slump though the Sale of Produce Ordinance (9 of 1933), which includes cacao among the products for which dealers must hold a licence, and the Unfermented Cocoa (prohibition of Export) Ordinances (6 of 1933 and 14 of 1934) are further steps in the direction of control.

(*To be continued.*)

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Plants Poisonous to Stock.

A very valuable account of American work upon plants poisonous to stock, by J. F. Couch, has recently been published (*J. Chem. Educ.* 14, Jan., 1937). The annual losses of livestock in the United States are estimated to exceed $2,000,000, and in Texas during one spring, animals valued at $300,000 died from the effect of one species. It is pointed out that, though poisonous wild species are widespread in the pastures, well-fed animals are usually reasonably safe; when the ranges are over-stocked, the hungry animals turn to the less palatable species of plants, and then the damage is done. Among the poisonous types of plants described are larkspurs, lupins and senecios containing alkaloids; glucoside-containing plants in which the aglycone may be cyanogenetic, or phenolic, or in which the glucoside is a saponin; solanine-containing plants, in which the solanine is at once both alkaloidal and solaninic—it is responsible for the occasional poisoning from sprouting potatoes;—plants containing proteins antigenic like the bacterial toxins such as the ricin in the castor oil bean, and the resinoid-containing plants of the Ericaceae. The chemical nature of these resinoid substances, which are difficult to crystallize, is little understood. It is very interesting to learn that the resinoid andromedotoxin is taken up by the bees from the flowers of some of these Ericaceous plants, and the honey then made may be very poisonous. Another obscure poison is the resinoid galitoxin found in the milkweed, *Asclepias galioides*. This makes this plant one of the most poisonous in the States, three ounces of the fresh plant being sufficient to cause the death of an adult sheep.—(*Nature*, Vol. 139, No. 3523, p. 806.)

* * *

The Influence of Excessive Liming on Boron Deficiency in Soils.—*By James A. Naftel.**

Greenhouse liming investigations begun in 1923 at the Alabama Agricultural Experiment Station showed negative results from liming on many of the soils of the Coastal Plains; such results are now referred to as over-liming injury. Over-liming on these soils was not overcome with moderate amounts of fertilizers containing nitrogen, phosphorus and potassium, nor were the additions of magnesium, calcium silicate, manganese, or iron of any value in preventing the injury caused by over-liming. The injury was associated with pH values above 6.8 and with soils of low base exchange capacities. The problem of over-liming remained unsolved until recently when a study on a Norfolk sandy-loam was reported which showed that *boron deficiency* was the causative agent.

Since the above studies on over-liming were conducted on the relatively light-textured soils of the Coastal Plains, it seemed important to determine whether similar results would be obtained on widely different soils in texture and origin. Accordingly, twenty soils representing fifteen soil series were obtained for conducting greenhouse pot experiments. These experiments were made using none, moderate and excessive amounts of lime, both with and without boron amendments to the soils.

Results of plant growth in pot cultures showed that excessive lime brought about over-liming injury on fifteen of the twenty soils under investigation. The injured plants showed evidence of boron deficiency, which was partially or completely overcome in the pot cultures treated with boron. Over-liming was independent of soil texture, but was related to the acidity and the degree of leaching to which the soils had been naturally subjected.

Liming decreased the water-soluble boron content of the soils directly with the amount of lime applied; this effect was uniformly true regardless of whether or not the soils were over-limed.

From the results of this investigation, liming evidently decreases the water-soluble boron in soils naturally low or deficient in boron; and excessive liming causes boron deficiency to higher plants.

* * *

A New Purine in Tea.

The known purines occurring in plants are caffeine $C_8H_{10}O_2H_4$, theobromine, $C_7H_8O_2N_4$, and theophylline, $C_7H_8O_2N_4$. These may be considered as end-products of purine metabolism in plants. In addition to these, some substances such as adenine and guanine, adenylic acid, vernine or guanosine, xanthine and hypoxanthine occur, the non-methylated purines being probably degradation products of plant nucleic acids. While uric acid has long been known as a characteristic oxidation product of purines in animals, it has only recently been found to exist in small quantities in plants (30-250 mgm. per kgm. dry plant). A methyl derivative of uric acid has now been detected for the first time in tea by T. B. Johnson (*J. Amer. Chem. Soc.*, 59, 1261; 1937). A residue from several million pounds of tea obtained in the commercial removal of caffeine was available and from this about 10 gm. of crystals were picked out. These were found by very careful examination, both chemical and crystallographic, to be 1, 3, 7, 9-tetramethyl-2, 6, 8-trioxypurine, derived from 2, 6, 8-trioxypurine (uric acid). It had been synthesized by Emil Fischer in 1884. As Prof. Johnson says: "By the discovery of this purine in tea, we not only increase the number of characteristically methylated purines occurring in the plant kingdom to four (theobromine, theophylline, caffeine and tetramethyl uric acid), but we also stimulate a new interest in the possible natural occurrence of other methyl derivatives of this series, and also in the mechanism of the plant metabolism of purines in general."—(*Nature*, Vol. 140, No. 3549, p. 814, 1937.)

* Abstracted from *Soil Sc. Soc. Proc.*, U.S.A., 1937.

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Blackstrap Molasses as Raw Material for Biochemical Industries (Olivarius Desaccharification Process).—*By Wm. L. Owen.*

It seems appropriate also to include in these series of articles (1) something about a process of utilizing cane molasses not for the production of chemical product, but rather for the recovery of sucrose. This process is the Olivarius, particulars of which have already been published in these columns (2). It has been applied on a plant scale, and is said to have shown promising possibilites.

Molasses is diluted to 45 to 50° Brix and adjusted to a pH of 6.3 to 7.0. The reducing sugars present are fermented off by a special culture of yeast with vigorous eration, and when complete, or at least when the r.s. are reduced to 3 per cent. or less, the fermented mash is immediately treated with alcohol of 85 to 90 per cent. strength in equal volume.

After thorough mixing, milk-of-lime is added, when a copious precipitate of organic impurities is thrown down, which is filtered off. The filtrate is carbonated with the gases from the fermenters to throw down the lime salts; again filtered, and lastly returned to the sugar-house for concentration and crystallization.

This elimination of the reducing sugars, and purification of the syrup, results, not only in a higher polarization of the fermented molasses but yields a liquor which is less susceptible to the darkening action of heat than the original, and which is of lower viscosity, and consequently is more easily filtered.

It should, however, be remembered that in removing the reducing sugars, we have at best, only converted a cane into a beet type of molasses, and that the sucrose is almost as soluble as before, with the same ash content. Unless, therefore, some means can be found of immobilizing the soluble ash constituents we shall have to depend on some modification of the Steffen process, or such other means of removing the sucrose other than by crystallization.

So the question arises whether the Steffen or like desaccharification process could profitably be applied. This would depend on the profits to be derived from the products of fermentation. From analyses made, it would appear that one would obtain approximately 0.3 lb. of alcohol per gallon of molasses treated, and about the same amount of CO_2. This of course would hardly pay for the handling of the fermentation process, and for the time required for the fermentation to be completed.

However, this cost could be largely compensated by the utilization of the author's protective inoculation process, (3) in which the fermented molasses could be used to film the raw sugar crystals, and only the excess of the fermented product subjected to desaccharification. This filming of raw sugars with torulae-processed molasses would not only give them a higher initial polarization, but would also stabilize its polarization during prolonged storage.—(*Int. Sugar Jr.* Vol. XL., No. 472, pp. 156-57, 1938.)

(1) *I.S.J.*, 1937, pp. 199, 281, 405.
(2) *I.S.J.*, 1932, pp. 49, 110, 481; 1933, p. 322; & 1936, p. 196.
(3) *I.S.J.*, 1923, p. 371.

* * *

Effect of Sunlight on Utilization of Nitrogen and Potash by Cane.—*By R. J. Borden.*

Experiments were made to study the relation between sunlight and the two plant foods, nitrogen and potash. Cane variety H.109 was grown in pots, of which one set was exposed to sunlight all day, one set only in the forenoon, and a third set only in the afternoon. All pots were well supplied with phosphate, but also with graded amounts of potash and nitrogen, the object being to see whether a deficiency of the growth factor, sunlight, could be compensated by strengthening the other factors, nitrogen and potash.

The results showed that the plants exposed all day to sunlight gave a much larger yield than those which had light for only part of the day, and that there was no essential difference between the yields of plants having forenoon or afternoon sunlight. It was also observed that the cane plants grown with full light contained a distinctly smaller percentage of moisture than those that had sunlight for only half the day.

This seems to explain why cane that is grown in regions of inferior light conditions (prevalence of cloudy weather, mountain shadows) has inferior juice quality, due to the higher moisture content. One practical indication is that the more potash and nitrogen supplied to the cane under poor light conditions, the greater the moisture content. Possibly therefore, better juices might be obtained under these conditions by being less liberal with these plant foods. At any rate, it is shown that attempting to overcome the effects of continued periods of overcast or cloudy weather by increasing nitrogen and potash applications is a fallacious procedure.—(*Int. Sugar Journal*, Vol. XL, No. 469, pp. 33-34, 1938.)

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Sixth Annual Report on Cacao Research, 1936, 51 pp., 1 plate. *Price* 5s.

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Markets have ranged as follows (c.i.f. per cwt.).

	Foreign.		*Preferential.*	
	s.	*d.*	*s.*	*d.*
28th April	5	0¾	8	9¾
5th April	5	0¾	8	10½
12th May	5	1½	8	9¾
19th May	5	0	8	9
26th May	5	0	8	9
2nd June	5	0	8	10½
10th June	5	0	8	11¾
(*10th June*, 1937)	6	7¼	10	4½

The Conference of the International Sugar Council opened on 27th April. The requirements of the free market during the current quota year were estimated at 3,050,000 metric tons compared with the total quota previously fixed at 3,508,500 metric tons. Further quota abandonments, aggregating 107,500 metric tons, were notified to the Council, thereby reducing the quantity available for the open market to 3,401,000 metric tons. The Council decided to reduce the quotas by 5 per cent. or 170,050 metric tons, thus bringing the total of quotas down to 3,250,950 metric tons. This figure makes a reduction of 529,050 metric tons from the basic quotas of 3,760,000 metric tons provided for in the agreement. There appears to be a surplus of 181,000 metric tons but attention is drawn to the fact that part of the United Kingdom stocks, which would normally be available for consumption, has been purchased by Government. It has been apparent for some considerable time that Far Eastern absorption of sugar would fall appreciably below previous estimates. Shipments from Java to China and Japan show a total reduction of 190,000 tons compared with the previous crop.

* * *

RUBBER.—Quotations for plantation sheet have ranged as follows:—

	Pence per lb.
27th April	5 13-16
4th May	5 5- 8
11th May	5 7- 8
18th May	5 3- 4
25th May	5 3- 8
1st June	5 9-16
8th June	5 11-16
(*9th June*, 1937)	9 7-16

Rubber consumption in America during April was disappointing, amounting to 27,984 tons compared with 30,487 tons in March and 51,797 tons in April last year. World stocks at the end of April are given as 566,572 tons, an increase of 6,198 tons on the month and of 160,164 compared with a year ago. This information has had a depressing effect on the market.

COCOA.—The almost uninterrupted price decline of the past month, reports of damage to the cocoa improperly stored at the Gold Coast and the improved technical position of the market are likely to cause a rally. However, until consumption and production show a favourable balance, it is doubtful if any material advance can be maintained. The price of Accra cocoa prompt shipment is 17*s.* 6*d.* and locally $4.65/4.50 per fanega is paid for Plantation Cocoa.

* * *

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association.

	American Mid.	*Egyptian Giza 7.*	*F.G.F. Sakel.*
29 th April	4.80	6.89	7.84
6th May	4.69	6.91	7.61
13th May	4.77	6.97	7.69
20th May	4.68	6.96	7.56
27th May	4.46	—	—
3rd June	4.43	—	—
10th June	4.49	—	—
(*11th June*, 1937)	7.06	—	10.84

Business in Manchester remained dull. Buyers are restricting purchases to immediate requirements. Prices have eased and the anxiety of producers is increasing. The Sea Island cotton market was generally neglected during May, a few bales of Leeward cotton being sold at 1*s.* 7*d.* per lb.

* * *

COFFEE.—London quotations for 16th May included: Santos superior, c.i.f. 29*s.* 3*d.*, contrasted with 53*s.* 3*d.* a year ago; and Rio No. 7. 19*s.* 6*d.*, contrasted with 42*s.* 6*d.* in 1937.

* * *

BANANAS are in quiet but steady demand at the unchanged price of £19 15*s.* per ton delivered London and £19 10*s.* nearest station Provinces. Brazilians are slow at the unaltered price of £16 delivered London and £17 Provinces.

* * *

GRAPEFRUIT.—Best Palestinian marks have been a firm market at from 13*s.* to 16*s.* per case. Prices for ordinary marks are unchanged at from 12*s.* to 14*s.* per case.

* * *

LIME PRODUCTS. *Lime Oil.*—There is only a small inquiry for Handpressed which is unchanged at 32*s.* 6*d.* per lb. Distilled is easier and quoted nominally at 22*s.* for small quantities; to effect important sales in present conditions a much lower price would have to be accepted. *Lime Juice.* There is no demand for Concentrated and Raw is slow of sale and nominally unchanged at 1*s.* 9*d.* to 2*s.* 3*d.* according to quality.—(*West India Committee Circular*, 19th May, 1938.)

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